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PAPERS AND PROCEEDINGS

OF

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R.S.—1

The Royal Society of Tasmania

Volume 104

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Royal Society of Tasmania

Papers and Proceedings Vol. 104

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Royal Society of Tasmania

Annual Report for the Year 1969

The Council submits to members the following report on the activities of the Society for the year 1969.

President

As mentioned in the last Annual Report, His Excellency the Governor, Sir Edric Bastyan was approached and asked to accept the office of President of the Society. It was with great pleasure that the members learned of Sir Edric's willingness to become President and so follow in the footsteps of all the Governors of the State since 1843.

The Society and its Headquarters

At the Annual Meeting held in March the question of the location of the Society and its library was considered by members. The Council of the Society had recommended that the offer of the University Council to provide appropriate accommodation in the library extensions at the University should be accepted under conditions drawn up and approved by the Honorary Solicitors of the Society. Members entered into a wide and useful discussion on the whole matter and finally agreed to adopt the Council's recommendation as far as housing the library was concerned, but on the express understanding that the Society will remain as an autonomous body. The matter of a meeting place was discussed further and points of view were put forward by members, some being in favour of retaining the present room for meetings, others feeling that the offer of the University to provide lecture rooms should be accepted, while yet others felt they would like the matter considered further. The Council was asked to review the whole matter of meeting places and report to the members at the Annual Meeting in 1970. It is expected the library move will be made about the middle of 1970.

Election

Elections were held for the vacant positions of Vice-President and members of Council. Dr E. R. Guiler was elected a Vice-President and Mr R. M. H. Garvie and Mr L. E. Wall were elected to the Council. Later in the year Mr A. R. Nielson was appointed to a casual vacancy in the Council.

Dr W. W. Wilson

The Society suffered a grievous loss late in the year through the death of the Senior Vice-President, Dr W. W. Wilson, who had been a member of the Society for many years. Dr Wilson had contributed to the Papers and Proceedings and had given lectures to the Society and was a member of Council for a number of years.

Papers and Proceedings

Volume 103 of the Papers and Proceedings was printed and distributed and once again a large number of volumes were sent to research institutions overseas from which we receive, by exchange, so many of the scientific and historical journals which have helped to make our library such a valuable one in certain respects. Five hundred and seventy volumes (books and periodicals) were added to the library during the year.

Lectures

Another interesting series of lectures was given during the year covering a wide range of topics. The Society is grateful to those specialists who made such a significant contribution to the Society through the lectures and discussions.

The following is a list of subjects and the speakers at the general meetings:—

April: Mr M. R. Banks, Geology Department, University of Tasmania, on 'The Geological History of Tasmanian National Parks'.

May: Dr Clifford Craig, on 'Old Tasmanian Pictures, Houses and Furniture'.

June: Professor A. G. Baikie, Department of Medicine, University of Tasmania, on 'Cytogenetic variation and the Natural History of Cancer'.

July: Dr Campbell Duncan, Pathology Department, Royal Hobart Hospital, on 'Hydatid Disease in Tasmania—Past, Present and Future'.

August: Dr E. R. Guiler, Zoology Department, University of Tasmania, on 'Tasmanian Devils'.

September: Dr June Cumbrae-Stewart, Food Preservation Division, CSIRO, on 'From Smokies to Flour'.

October: Dr R. C. Menary, Senior Lecturer in Horticulture, University of Tasmania, on 'Phosphorus in Horticulture'.

November: Professor R. M. Mitchell, Department of Surgery, University of Tasmania, on 'Transplantation of Tissues and Organs'.

Membership

The total membership at the end of the year was 569. Of this number, four are Honorary Life Members and 231 are members of the Northern Branch.

Northern Branch

The Branch again functioned with decided success and their general meetings and excursions proved popular and interesting.

Fellows

In the earlier years of the Society's history both Fellows and Members formed the membership. At a later date the term 'Fellow' was dropped since when all in the Society had been listed as 'Members'. This matter was raised at the last Annual Meeting and it was agreed that consideration should be given to re-introducing 'Fellows' of the Society.

Acknowledgments

Without the generous help and assistance given by various libraries and many organisations and individuals, the Society would not be able to function as it does. The Society is particularly grateful to, and acknowledges the assistance provided during the year by, the Government of Tasmania, the Trustees of the Tasmanian Museum and Art Gallery, the Queen Victoria Museum in Launceston, the Press, Radio and Television stations, the State Library, the University of Tasmania, and the many individuals who have assisted the Society so generously.

Northern Branch

Annual Report for the Year 1969

Following the Annual General Meeting of the Northern Branch, held on 28 March 1969, the Branch Council comprised:—

Chairman—Dr J. C. H. Morris
Vice-Chairman—Mr J. N. Gee
Hon. Secretary and Treasurer—Mr W. F. Ellis
Past Chairman—Mr Justice G. H. Crawford
Council Members—Mr G. H. Stancombe, Mr N. R. Harvey, Mr D. Walter, Mr H. W. Askeland, Mr R. S. Smith
Hon. Auditor—Mr R. C. A. Pitt.

Dr Morris and Mr Justice Crawford were appointed representatives of the Branch on the Council of the Society in Hobart. Mr W. F. Ellis represented the Branch of the Council of the Australian and New Zealand Association for the Advancement of Science.

Membership

The membership of the Northern Branch on 31 December 1969 totalled 231.

Activities

Eleven general meetings were held at which the following lectures were delivered:—

28 February 1969: 'Tasmania Rejects New Education—the Role of W. L. Neale, 1904-1909', by Mr D. V. Selth.

28 March 1969: 'Rainmaking', 'Seals of Macquarie Island', 'Coaching Days' and 'Rock Art of the Cleland Range' (scientific films).

2 May 1969: 'Launceston's Twenty Theatres', by Mr M. C. Oldaker.

23 May 1969: 'Australians in Antarctica', by Mr L. G. Walkem.

20 June 1969: 'You were never taught geography . . .', by Mr K. M. Beaumont.

18 July 1969: 'Progress in the application of radioisotopes in Australia', by Dr J. N. Gregory.

22 August 1969: 'Geology of some Tasmanian National Parks', by Mr M. R. Banks.

25 September 1969: 'A Perspective of African History', by Sir George Cartland.

24 October 1969: 'The Future of Biological Survey in New South Wales', by Dr H. S. Recher.

21 November 1969: 'Timber — Tasmania's Happy Heritage', by Mr B. A. Lyons.

12 December 1969: Members' lecturettes—

'Beach Mining and Conservation', by Mr D. Steane.

'Historic Sites on the North-West Coast', by Mr H. V. Turner.

'Turn Back the Hands of Time', by Mr N. R. Harvey.

'Equi-angular Spiral in Nature', by Mr D. McDonald.

'Some Memorable Monuments', by Mr G. H. Stancombe.

'From Bus to Bedroom', by Mr Justice G. H. Crawford.

Excursions

An inspection of the Goliath Cement Company's installations at Railton was held on 20 July 1969.

A tour of the Triabunna-Orford district and Maria Island was held on 29-30 November 1969, and was an outstanding success.

An excursion to study the freshwater biology of the North Esk River, arranged for 21 May 1969, was cancelled owing to severe flooding.

Council

The Council of the Northern Branch met six times during the year. In addition to the normal business of the Branch, sub-committees have been inaugurated or continued for the following purposes:—

The establishment of a memorial to Matthew Flinders;
A survey of information from cemeteries in northern Tasmania;

The arrangement of general meetings.

The Branch records with regret the decease of Mrs I. J. Mead, who contributed extensively to our activities and who had served on the Branch Council for many years as a member, Hon. Secretary and Chairwoman.

We note also with regret the decease of Dr W. Wilson, Senior Vice-President of the Society. Dr Wilson had shown interest and understanding toward this Branch, which will be missed greatly.

[*Manuscript received 3 February 1969*

THE DEVONIAN CORAL FAUNA OF THE POINT HIBBS LIMESTONE, TASMANIA

By

J. S. JELL AND D. HILL

University of Queensland

(With six plates and two text figures)

ABSTRACT

Of the fourteen species (six new) assigned to eight rugosan and five tabulatan genera, identified in the coral fauna of the Point Hibbs Limestone of the west coast of Tasmania, eleven are systematically examined and illustrated. The genus *Endophyllum* is discussed in relation to *Sinospongophyllum* and *Tabulophyllum*. The microstructure of Silurian and Devonian cystimorphs is considered. The age indicated by the coral fauna is within the range Siegenian to Lower Couvinian and is possibly Emsian.

Only three of the species of corals from the Point Hibbs Limestone of the west coast of Tasmania have been described previously (Hill, 1942b). With few exceptions the new material on which this study is based was collected and kindly loaned to us by Maxwell R. Banks of the Geology Department, University of Tasmania. The catalogue numbers of these specimens are prefixed by UTGD. A few specimens housed in the Queen Victoria Museum of Launceston were loaned to us by the Director, Mr W. F. Ellis; these are indicated by QVM. Specimens from the collections of the Australian Museum, Sydney, National Museum of Victoria, Melbourne and the University of Queensland, Brisbane are prefixed by AM, NMV and UQ respectively. Paratypes are not cited by number in the text, but are identified as such on their museum labels.

The location of the Point Hibbs Limestone is shown on text-figure 1, redrawn from the Geological Map of Point Hibbs (Geology of Tasmania one inch series—University of Tasmania Geology Department 3375) by M. R. Banks assisted by N. Ahmad and R. J. Ford, and published in 1970. Point Hibbs has geographical co-ordinates 145° 15′ E 42° 37′ S.

The coral fauna contains: *Pseudamplexus princeps?* (Etheridge), *Martinophyllum approximans* (Chapman), *Gurievskiella abyssus* sp. nov., *Disphyllum repansum* sp. nov., *Endophyllum banksi* sp. nov., *Tryplasma* spp., *Rhizophyllum enorme* Etheridge, *Plasmophyllum* (*Plasmophyllum*) *tasmaniense* sp. nov., *Favosites goldfussi* d'Orbigny, *F. careyi* sp. nov., *Squameofavosites bryani* (Jones), *S. bryani* var. *ramosus* var. nov., *Cladopora* sp., *Thecostegites ejuncidus* sp. nov. and *Aulopora* sp.

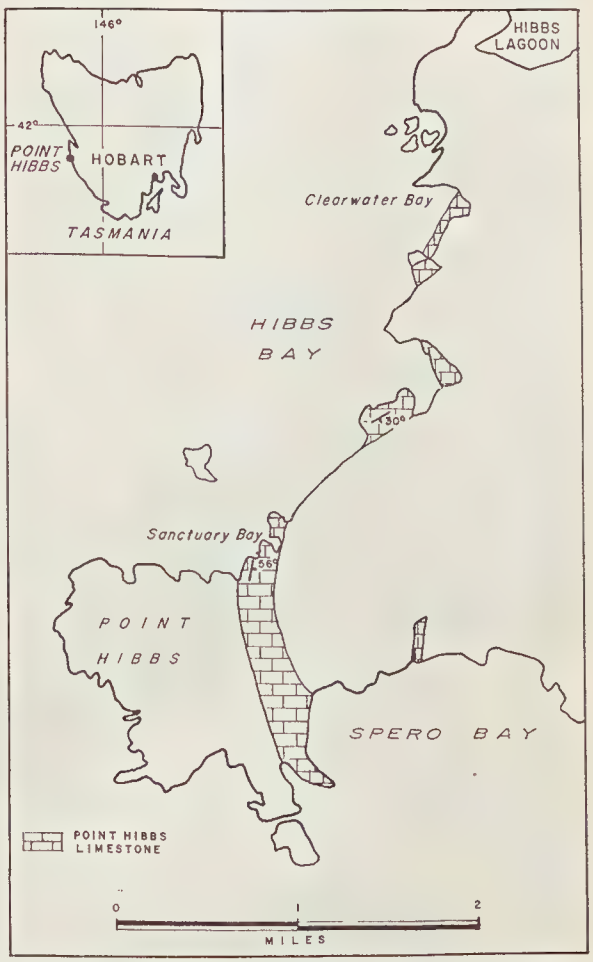


FIG. 1.—Map showing the distribution of the Point Hibbs Limestone, west coast of Tasmania.

AGE

Banks (*in* Talent & Banks, 1968) after a preliminary study of the entire fauna, suggested an Emsian or Eifelian age, most likely late Emsian. Philip & Pedder (1968), after a preliminary study of corals and conodonts, correlated the Point Hibbs fauna with that of the Coopers Creek Formation and the Lilydale Limestone of Victoria, and considered it Lower Siegenian.

The Point Hibbs Limestone shares two coral species with the Coopers Creek Limestone of Victoria, which is considered Lower Siegenian mainly on evidence from conodonts by Philip & Pedder (1968) and Upper Siegenian (Talent, 1965, p. 183) or Lower Emsian (Talent *in* Talent & Banks, 1968, table 1) mainly on the regional stratigraphic and brachiopod evidence. These species are *Martinophyllum approximans* (Chapman) and *Squameofavosites bryani* (Jones). The latter ranges in Victoria up to the Murrindal Beds of the Buchan district which Philip & Pedder (1968) consider Emsian and which Hill (1950) and Talent (*in* Talent & Banks, 1968) consider Couvinian. The only known overseas occurrence of *Martinophyllum* is in the undifferentiated 'Eifelian' of the eastern slopes of the Urals. *Squameofavosites* entered in the Ludlovian or Skalian of Podolia, was very common in Europe and Asia during the Lower Devonian and became extinct within the Couvinian. *Rhizophyllum enorme* Etheridge occurs elsewhere in Australia in the Siegenian? to Emsian Garra Beds (Strusz, 1968) of New South Wales and Mt Etna Limestone of Queensland, which Hill (1942a) considered Coblenzian (Emsian) but which Philip & Pedder (1968) regard as within the range Upper Siegenian to top of Emsian or perhaps Eifelian. In the U.S.S.R., *R. enorme* (or closely similar species) is illustrated from the Krekov and Maly Bachat Beds (Siegenian to Emsian) of the Salair, and from rocks of similar age in south Fergana and the northern Urals. In the U.S.A. a specimen compared to *R. enorme* is illustrated from the Gedinnian or Siegenian of Nevada. *Favosites goldfussi* has a long range, Lower and Middle Devonian in Eurasia and Australia. *Endophyllum banksi* sp. nov. is reasonably similar to the Couvinian or Givetian *E. yunnanense* Mansuy from China and the Givetian and Frasnian? *E. abditum* Edwards & Haime from Devon. The range of *Endophyllum* overseas is Salairka Beds ('Upper Emsian, Lower Eifelian' of the Salair) to the Frasnian. Our new species of *Gurievskiella, Disphyllum, Plasmophyllum* (*Plasmophyllum*), *Favosites* and *Thecostegites* are not very similar to other described species of these genera. *Gurievskiella* ranges in Victoria from the Coopers Creek Formation to the Emsian (Philip & Pedder, 1968) or possibly early Couvinian (Hill, 1950) Buchan Caves Limestone, and in the U.S.S.R. from the Maly Bachat Beds of the Salair ('Lower Emsian') to the 'Eifelian' of the Urals, and in China, in the Middle Devonian. *Disphyllum* and *Thecostegites* range throughout the Devonian, *Thecostegites* entering in the late Lower Ludlow in the Grebeni horizon of the Polar Urals (Dubatolov, *et al.*, 1968). *Plasmophyllum* (*Plasmophyllum*) ranges throughout the Lower and Middle Devonian. *Tryplasma* is predominantly Silurian and *Pseudamplexus* predominantly Lower Devonian, but each occurs sparsely in the Couvinian. *Cladopora* sp. and *Aulopora* sp. are not significant of age.

It seems to us, therefore, that the age of the Point Hibbs Limestone lies within the range Siegenian to Lower Couvinian, and that an Emsian age is possible.

SYSTEMATIC DESCRIPTIONS

Order RUGOSA Edwards & Haime, 1850

Suborder Streptelasmatina Wedekind, 1927

Superfamily *ZAPHRENTICAE* Edwards & Haime, 1850

Family MYCOPHYLLIDAE Hill, 1940

Genus **PSEUDAMPLEXUS** Weissermel, 1897

Pseudamplexus princeps? (Etheridge), 1907

Plate 1, fig. 1

Part of a large cylindrical corallite UTGD 52066 is doubtfully identified as *Pseudamplexus princeps* (Etheridge), 1907.

Family PHILLIPSASTRAEIDAE C. F. Römer, 1883

Subfamily PARADISPHYLLINAE Jell, 1969

Genus **MARTINOPHYLLUM** Jell & Pedder, 1969

Type species, diagnosis, discussion and distribution: See Jell & Pedder (1969).

Martinophyllum approximans (Chapman, 1914

Plate 1, figs 10-13

Cyathophyllum approximans Chapman, 1914a, p. 304, pl. 47, figs 5, 6; 1914b, p. 129, fig. 69A.

Heliophyllum ?chillagoense (Etheridge); Hill, 1942b, p. 6, pl. 2, figs 3a, b.

Hexagonaria approximans (Chapman); Hill, 1954, p. 107, pl. 6, figs 3a, b; Philip, 1962, p. 177, pl. 24, figs 4, 8, 9, text-fig. 4a.

Hexagonaria aff. *approximans* (Chapman); Hill, 1954, p. 108, pl. 6, figs 4a, b.

Martinophyllum approximans (Chapman); Jell & Pedder, 1969, p. 738, pl. 96, fig. 5.

Martinophyllum sp. *B.* cf. *M. approximans* (Chapman); Jell & Pedder, 1969, p. 739, pl. 96, figs 6, 8.

Lectotype (chosen Hill, 1954, p. 107): NMV P1247 and thin sections P12896, P17902, P17903, P20521, P20522, and possibly P24052 from a limestone of the Coopers Creek Formation, Coopers Creek, near Walhalla, Victoria; Philip & Pedder (1968), mainly on evidence from conodonts, consider the age Lower Siegenian. Talent mainly on regional stratigraphic and brachiopod evidence, considers it Upper Siegenian (1965, p. 183) or Lower Emsian (*in* Talent & Banks, 1968, table 1).

Diagnosis: Medium to large *Martinophyllum* (corallite diameter 6 to 20 mm) with 30 to 50 long, thin or fusiform, smooth or carinate septa that may be retiform peripherally; dissepimentarium wide, commonly everted; tabularium narrow with elevated tabularial floors.

Description of Tasmanian material: The twenty-six coralla from Point Hibbs are cerioid, broadly conical with convex upper surfaces, the largest

colony being 18 cm in diameter and 10 cm in height. On the calicular surface the corallites are outlined by their slightly elevated walls. The calicular platforms are flat or slightly everted but axially are steeply declined towards a deep flat-bottomed pit. The adult corallites vary from 8 to 18 mm in diameter (mean for all coralla is 11.6 mm). They are polygonal with straight or slightly crenulate walls in the mature parts of a corallum but in the younger stages where increase is rapid their walls are curved. Increase is peripheral and non-parricidal. Initially the septa of the parent and daughter corallites are continuous. A dividing wall is progressively inserted only after dissepiments are developed in the offsets; some offsets become walled off at diameters of 2 mm while others are still without a fully developed dividing wall at a diameter of 7.5 mm. The common wall between corallites is 0.15 to 0.3 mm thick.

The septa are radial and in two orders with sixteen to twenty-five in each (commonly twenty at diameters of 11 to 12 mm). The major septa may extend to the axis but are commonly evenly withdrawn leaving an axial space up to 3 mm in width. The minor septa do not project beyond the dissepimentarium. The septa of both orders are commonly thin or slightly fusiform, smooth, and straight but some are strongly dilated in the inner dissepimentarium becoming strongly fusiform while others are carinate and in the outer dissepimentarium may become retiform. The carinae are of the zig-zag type and generally short. In the tabularium the major septa are thin or rarely thickened (UTGD 52003) straight or flexuose and occasionally carinate; in forms with a wide axial space the septa may be represented by discrete spines axially. The trabeculae are fanned over the inner dissepimentarium becoming vertical or slightly inclined upwards and outwards at the periphery.

The tabularium is narrow, 4 to 5 mm in diameter. The tabularial floors are arched. In forms in which the major septa are withdrawn from the axis, the tabulae are complete and mesa-shaped, often sagged axially. In others with the major septa extending to the axis a periaxial series of flat tabellae and an axial series of convex tabellae inclined upwards to the axis are developed.

The broad dissepimentarium is composed of numerous, small, globose dissepiments commonly differentiated vertically into alternating zones of smaller and larger plates. In the larger corallites, small, globose, lateral dissepiments lining the septa may intervene between the septa and the normal dissepiments. The tendency for the septa to become retiform at the periphery in the larger corallites gives the outer dissepimentarium a lace-like appearance.

Comparisons: The study of eleven topotypes (UQF 57617, 57619-57626, NMV P24502) of *M. approximans* shows that variation at the type locality is greater than previously thought. The coralla are small, rarely exceeding 10 cm in diameter and adult corallites range from 7 to 13.5 mm (mean of twenty-eight corallites, 10.1 mm). Their septal number varies from 34 to 46 (mean 37.3). The septa are variously modified, the commonest being dilated and with or without carinae, becoming fusiform in transverse section except where the dissepimentarium is narrow when they are cuneate; others may be strongly retiform in the outer dissepimentarium. The septa reach the axis in 37% of the corallites and in 10% are withdrawn more than half the radius of the tabularium. Except in forms with the septa withdrawn from the axis the tabularia are biserial with the axial tabellae tent-shaped and producing a clisioid structure. The dissepimentarial floors are commonly everted.

Eight specimens (UQF 3681-3, 57628-30, NMV 15954, 26043) from the Coopers Creek Formation at Tyers Quarry, Tyers, near Walhalla are from larger coralla up to 25 cm in diameter. The corallites are generally larger, from 10 to 18 mm in diameter (mean of sixteen corallites 13.4 mm) and with more septa, 34 to 48 (mean 41.4), than the topotypes. The septa show the same variation in modification as the topotypes although the commonest form is that of heavily carinate septa becoming retiform in the outer disseptimentarium. In 72% of the corallites the septa are either retiform or fusiform and carinate while in only 13.6% are they thin and non-carinate. The major septa are generally long extending more than half the radius of the tabularium and in 56% they reach the axis. The tabularium is generally tent-shaped and biserial. The dissepimentaria are broad and everted.

TABLE I—PERCENTAGES OF CORALLITES WITH VARIOUS TYPES (A-C) OF SEPTAL MODIFICATION

Locality	N	*Septal modification*				
		A1	A2	B1	B2	C
Coopers Creek	36	19.4	5.5	36.1	33.3	5.5
Tyers	22	13.6	4.5	4.5	23.3	50.5
Point Hibbs	87	42.5	10.3	16.1	19.5	11.5

N, number of corallites; A1, thin non-carinate; A2, thin, carinate; B1, fusiform, non-carinate; B2, fusiform, carinate; C, retiform.

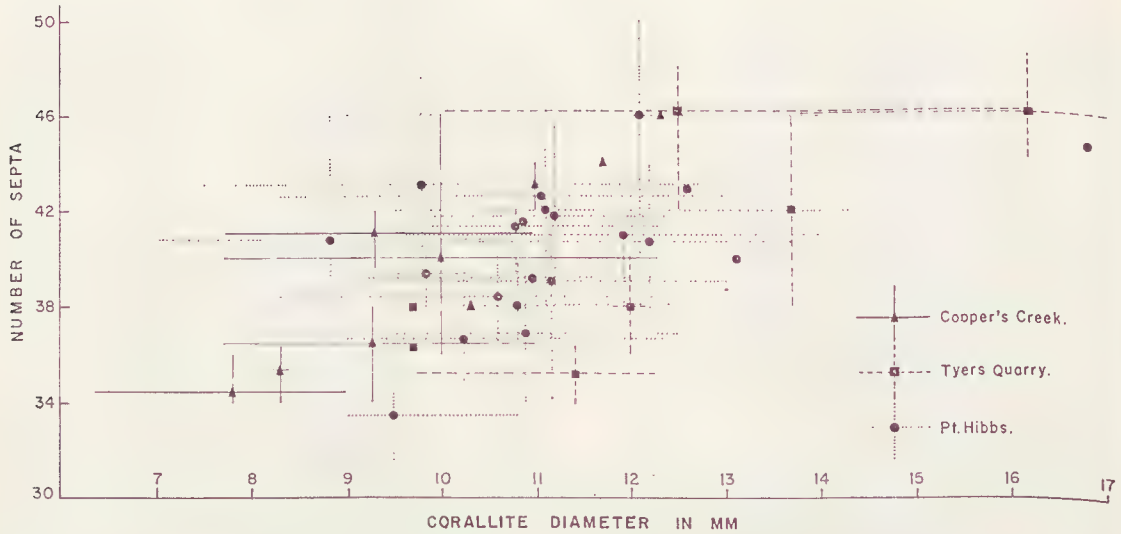


FIG. 2.—Plots of septal number and corallite diameter for *Martinophyllum approximans* from Coopers Creek and Tyers Quarry, Victoria and Point Hibbs, Tasmania, showing the means for each corallum and the range of variation within the corallum.

The Point Hibbs material is intermediate between the Coopers Creek and Tyers material in size of corallum (maximum diameter 18 cm), diameter of corallite (range of 103 corallites 8 to 18 mm, mean 11.6 mm) and septal number (of 103 corallites 32 to 50, mean 40.2), see text-figure 2. Although the septa show the same degree of modification as the Victorian material, the commonest are thin, noncarinate and withdrawn from the axis. Only in 20% of the corallites do the major septa reach the axis and in 23% they do not extend more than half the radius of the tabularium from the axis. The tabularia are simpler and contain more complete tabulae than the Victorian material. The dissepimentarial floors are flatter and less commonly everted than in the Coopers Creek and Tyers material.

The collections from the three localities, although their characteristic septal structure, mean corallite diameter and mean septal number are distinct, show similar variation and are considered conspecific. However, larger collections from the Victorian localities may show that subspecies should be distinguished for the three localities.

A specimen UQF 17115 from Bell Point, Waratah Bay [presumably from the Waratah Limestone but possibly from the Bell Point Limestone] figured as *Hexagonaria* aff. *approximans* by Hill (1954, pl. 6, figs 4a, b) is similar to the larger of the topotypic specimens and has been discussed by Jell & Pedder (1969). A second specimen (UQF 17120) from Waratah Bay referred to *Hexagonaria* aff. *approximans* by Hill, 1954, p. 108, from the base of *Amphipora* limestone [Bluff Member of the Waratah Limestone] south of the Bluff is not considered conspecific with the first as it shows strong yardarm carinae that are not known in *M. approximans*.

The septal modification giving retiform septa is similar to that illustrated by Haller (1935) and by Birenheide (1963) for species referred to *Cyathophyllum* and that by Birenheide (1964, pl. 8) and by Wedekind & Vollbrecht (1931, pl. 20) for species of *Plasmophyllum* (*Mesophyllum*). The arrangement of lateral dissepiments in rows parallel to the septa is also seen in these same genera (Birenheide, 1963, pl. 50 and Vollbrecht, 1926, pls 15, 16).

Genus **GURIEVSKIELLA** Zheltongova, 1961

Gurievskiella Zheltonogova, *in* Zheltonogova & Ivaniya, 1961, p. 403; Jell & Hill, 1969, p. 11.

Type species, diagnosis, discussion and distribution: See Jell & Hill (1969).

Gurievskiella abyssus sp. nov.

Plate 1, figs 2-9

Latin, *abyssus*—deep pit, reference to calice.

Holotype: UTGD 52033/2 from the Point Hibbs Limestone, Point Hibbs, western Tasmania; Emsian?

Diagnosis: Solitary to weakly compound Rugosa with very deep calice. Septa fusiform, extending unequally to the axis, carinate peripherally; cardinal septum commonly short; counter septum longest of major septa; fossula may be weakly developed; trabeculae monacanths with their fibres nearly parallel to trabecular axis. Tabularium wide, tabulae broad and arched with upturned margins. Dissepimentarium narrow, dissepiments numerous, small, globose, evenly declined axially.

Description: The corallum is either solitary or compound in which two generations of offsets form

a loosely united bushy colony. The corallites are moderately small, occasionally curved, and trochoid becoming ceratoid to sub-cylindrical in the larger specimens. The holotype is a slightly curved, trochoid corallite 18 mm in calicular diameter and approximately 33 mm in height; it shows one peripheral offset. The maximum corallite diameter measured was 22 mm in a corallite 35 mm in height. The calice is characteristically deep with steep sides and a narrow margin. Its floor is arched with a narrow periaxial trough and broad high median boss. Smaller corallites with the calice extending almost to the proximal tip are considered juveniles. The epitheca where preserved is thin. The exterior of the corallites shows prominent septal grooves, broad interseptal ridges and less obvious growth annulations. Increase is peripheral, non-parricidal; commonly four offsets are developed simultaneously.

In adult corallites there are usually twenty-nine to thirty-five septa of each order. They are pinnately arranged about a long counter septum and a commonly reduced cardinal septum. The cardinal fossula is only sometimes apparent in transverse section. The alar septa are commonly longer than the metasepta. In specimens in which the fossula is distinguishable, it is on the concave side of the curved corallites. The septa are fusiformly dilated in the dissepimentarium where they are commonly carinate or vepreculate. Carinae are short and irregular. The major septa extend unevenly to the axis. They are commonly thin midway between the tabularial boundary and the axis but dilated in an axial zone where they become irregular, often turned aside and commonly joined or interfingered with adjacent septa. Axially some are represented by discrete traberculae.

The septa are monacanthine. The fibres of a trabecula diverge only slightly from its axis. The fibres or groups of fibres may be elongated laterally to produce vepreculae or carinae. No central axis can be seen in the elongated lateral bundles to suggest that they are rhipidacanths.

The tabularium is wide with domed tabularial floors except for a narrow marginal furrow. It is deeply concave beneath the cardinal fossula. The tabulae are domed with upturned edges; in larger specimens they may be replaced by flat to elongate convex tabellae.

The dissepimentarium is narrow, only occasionally consisting of more than three rows of dissepiments. The dissepiments are small, globose and steeply inclined inwards and downwards; no areas of eversion of the dissepimentarial floors are developed. In the smaller specimens the high narrow calical lips have only a single series of small dissepiments.

Remarks: The generic affinities of this species are obscure. In its deep calice and bilateral symmetry it resembles *Ceratophyllum* Gürich, 1896, with type species *C. typus* Gürich, 1896, p. 181, from the Stinkkalken, Szydlowek, Poland, Middle Devonian (possibly Lower Givetian). It differs however in septal microstructure, in not possessing rhipidacanths, and in its steeply and evenly declined dissepimentarium. *Kunthia* Schlüter, 1885, with type species *K. crateriformis* Schlüter, 1885, p. 7; 1889, pl. 1, figs 10, 11, from the Middle Devonian of Esch, Eifel district, Germany, has a similar deep calice and has fusiform septa with short irregular carinae of the phillipsastraeinid type. However, the type specimen of *K. crateriformis* has not been sectioned and its internal structure is not known.

In the new species, the septa, their bilateral arrangement and their microstructre are typical of *Gurievskiella* to which we refer it with some reservation. Its dissepimentarium of small dissepiments evenly declined axially is as in *Disphyllum* whereas in *Gurievskiella* the dissepimentarium is usually everted. The absence of eversion in *G. abyssus* may result from the narrowness of its dissepimentarium and the height of the calicular rim. *G. abyssus* does not resemble any other previously described species.

Subfamily DISPHYLLINAE Hill, 1939

Genus **DISPHYLLUM** de Fromentel, 1861

Disphyllum de Fromentel, 1861, p. 302; Lang & Smith, 1934, p. 80; Lang & Smith, 1935, p. 544; Smith, 1945, p. 20; Hill & Jell, 1970b (in press).

Type species, diagnosis and distribution: See Hill & Jell (1970b).

Disphyllum repansum sp. nov.

Plate 2, figs 3, 4, 6-9

Latin, *re*—again, *pando*—to spread.

Holotype: UTGD 52805 from the Point Hibbs Limestone, Sanctuary Bay, Point Hibbs, western Tasmania; Emsian?

Diagnosis: *Disphyllum* of essentially phaceloid habit in which the tall cylindrical corallites are laterally expanded periodically so that the corallum becomes periodically cerioid. Major septa long but do not reach the axis; tabularial floors arched, tabellae large and convex.

Descriptions: The coralla are phaceloid and the corallites lie closely together, never more than 8 mm apart. The corallites are initially trochoid to ceratoid but become cylindrical and tall; the average diameter is 11 mm and the largest 13.5 mm. Periodically within a corallum the corallites are expanded laterally so that adjacent corallites are in contact for up to 7 mm of their length and in transverse section the colony then appears cerioid. The calices usually have a narrow calicular rim and slope evenly downwards to a moderately deep axial pit except where the corallites are in contact when the rim becomes broad and even everted in places. The corallite walls are thin, 0.2 mm thick, and externally show narrow septal grooves and broad rounded interseptal ridges. Increase is predominantly peripheral and non-parricidal but some offsets develop from the median parts of the tabularium. In at least one corallite of QVM 834, increase is parricidal; a large corallite gave rise to seven peripheral offsets from its dissepimentarium; simultaneously it grew forward from its wide axial region and then gave rise to two axial parricidal offsets (pl. 2, fig. 4). Increase in the corallum is commonly associated with the lateral expansion of the corallites.

There are thirty-eight to forty-eight (mean forty-two) septa arranged in two orders. They are straight and thin or peripherally dilated to become cuneate in transverse section, except at

the lateral expansions of the corallites where they are thin and corrugated or straight and fusiform. They are either smooth or carry short carinae especially where the septa are dilated. The major septa are two-thirds to four-fifths and the minor septa a little more than half, the radius of the corallite. The septal microstructure is disphyllinid with wide monacanths directed upwards and inwards. The tabularium is about half the diameter of the corallite. In juvenile corallites the tabulae are simple, complete and horizontal. In adult stages they become arched, sometimes with a median flattening or depression, and consist of elongate convex tabellae. The dissepiments are small, uniform and globose, evenly inclined towards the axis except where the dissepimentarium is expanded in the lateral swellings of the corallites; here they are larger, more elongate and horizontally based or declined peripherally.

Remarks: In growth form and internal structure *D. repansum* is distinct from all previously described species of *Disphyllum*. Its colony form, however, resembles that of *Eridophyllum colligatum* (Billings) from eastern North America as figured by Rominger (1876, pl. 38, fig. 3) from drift material of the Corniferous limestone of Michigan and by Lambe (1901, pl. 13, fig 2) from the Corniferous limestone of Walpole, Ontario. Oliver (1968, table III) lists *E. colligatum* from the late Lower Devonian Bois Blanc Formation of Ontario and western New York.

Suborder **Columnariina** Rominger, 1866

Family CHONOPHYLLIDAE Holmes, 1887

Subfamily ENDOPHYLLINAE Torley, 1933

Genus **ENDOPHYLLUM** Edwards & Haime, 1851

Type species: by subsequent designation of Schlüter (1889, p. 51), *Endophyllum bowerbanki* Edwards & Haime, 1851, p. 394; 1853, p. 233, pl. 53, fig. 1; Barton, near Torquay. The massive limestone of Barton Quarry, from which Edwards & Haime's type material presumably came, is now (Scrutton, 1968, p. 188) considered Upper Givetian. The neotype of this species, selected 'at least provisionally' by Jones (1929, p. 87), is British Museum specimen R1448 from Rocky Valley, Torquay; Upper [?] Devonian.

Diagnosis: Sub-cerioid, cerioid or thamasterioid Rugosa; corallites large with marginarium consisting of a septal stereozone broken up by large lonsdaleoid dissepiments, septa long, thinner and commonly convolute in wide tabularium, tabulae flat-topped domes with upturned edges.

Remarks: In referring our new species to this genus, we have considered the two morphologically similar and probably related but commonly solitary genera *Sinospongophyllum* Yoh, 1937 (type species *S. planotabulatum* Yoh, 1937, p. 64, pl. 6, fig. 2, Middle Devonian of Kwangsi, China) and *Tabulophyllum* Fenton & Fenton, 1924 (type species *T. rectum* Fenton & Fenton, 1924, p. 31, pl. 6, figs 8-12, Frasnian [Cerro Cordo Member, Lime Creek Formation], Hackberry Grove, Iowa, U.S.A.).

Sinospongophyllum planotabulatum was originally described as solitary. Fontaine (1966) has referred to it two specimens from the Middle Devonian of Poshi, Yunnan, which he interprets as simple coralla, capable of producing offsets, associated in groups, thus resembling fasciculate and cerioid coralla. The thin sections he figured (pl. 14, figs 1, 3) are indeed of similar character to those of the lectotype (the specimen from Chiao-ting, Ping-lo, Kwangsi figured by Yoh, 1937, pl. 6, figs 2a, b, and chosen by Engel & Schouppé, 1958, p. 95). We agree with McLaren (1964, p. 19) that the septal structure of *S. planotabulatum* is sufficiently distinctive to maintain *Sinospongophyllum* as a genus separate from *Neosponsophyllum* Wedekind, contrary to the opinion expressed by Engel & Schouppé.

We cannot agree with Fontaine (1966) that *Endophyllum yunnanense* Mansuy (1912) should be transferred to *Sinospongophyllum*. We think its growth form to be sub-cerioid like that of *Endophyllum abditum*. Jones (1929, p. 87) described *E. abditum* Edwards & Haime (1851) as subphaceloid or cerioid; typically its corallites are contiguous but incompletely so, having free rounded angles. The thin sections from the holotype of *E. yunnanense* figured by Fontaine (1966, pl. 2, fig. 1; pl. 4, fig. 1) show peripheral offsets, and tightly fitting polygonal corallites with angular corners. Jones' illustrations of both *E. bowerbanki* and *E. abditum* and those given by Smith (1945, pl. 31, fig. 3) of *E. abditum* show septal carination similar to that in *Sinospongophyllum* and *E. yunnanense*. One of the features which Fontaine used to distinguish *Sinospongophyllum* from *Endophyllum* was the development of small convex tabellae at the edge of the flat top of the axial tabellae. This feature is found in many corals with domed tabulae, commonly associated with a shortening of the major septa by withdrawal from the axis; the tabulae then tend to sag axially and to be reinforced at the inner edges of the septa by these small convex tabellae. This phenomenon is well seen in *Entelophyllum* and is sporadically developed in the aphroid *Endophyllum schlüteri* and in the cerioid *Endophyllum* sp. figured by Hill, Playford & Woods (1967, pl. D8, fig. 2).

We consider *E. abditum* and *E. bowerbanki* to be so similar in their internal morphology that they must be congeneric. *E. abditum* ranges in growth form within the one colony from closely phaceloid to subcerioid and cerioid; *E. bowerbanki* ranges similarly from cerioid to aphroid.

We retain *Sinospongophyllum* for solitary or weekly colonial species and note that it ranges from the Lower Devonian at least into the Middle Devonian. We find *Tabulophyllum* to be useful for solitary coralla or coralla which produce only one generation of offsets, with relatively thin, and commonly short septa, less closely spaced than in *Endophyllum*, but with a lonsdaleoid marginarium and tabulae that are flat-topped domes with upturned edges. Much further research is however required into relationships between *Tabulophyllum*, *Sinospongophyllum* and *Endophyllum*.

Distribution: Lower Devonian of Tasmania, Upper Emsian or Lower Eifelian of the Salair, Siberia; Middle Devonian of Europe, Asia and eastern Australia; ?Upper Devonian of Europe and Asia.

Endophyllum banksi sp. nov.

Plate 2, figs 1, 2, 5

Named in honour of Maxwell R. Banks, Geology Department of the University of Tasmania.

Holotype: UTGD 52091, Point Hibbs Limestone, southern shore of Sanctuary Bay, north side of Point Hibbs, western Tasmania; Emsian? Some fifteen paratypes.

Diagnosis: Large phaceloid to sub-cerioid colonies of large corallites; increase peripheral and commonly parricidal; dissepimentarium lonsdaleoid; tabularium wide, axial tabellae wide, flat-topped, domes; periaxial tabellae not regularly developed, flat or concave; septa long, crowded, thickened to contiguity peripherally; major septa may be convolute or grouped in tabularium; fossula slightly expanded axially.

Description: The holotype, a fragment, consists of two very large pieces, the larger 30 cm across. The corallites are conical, large, up to 45 mm in diameter. At this diameter the tabularium is 13 mm wide. A few corallites are oval in section. They are closely spaced and are commonly in contact with neighbours, when they become polygonal through mutual pressure. The calice has a sloping platform and shows the upper edges of the crowded long septa, each as a continuous radial ridge. Increase is peripheral, offsets arising with a diameter of 5 mm or more in a ring or partial ring around the dissepimentarium; the parent commonly fails to grow further; the offsets expand rather rapidly to adult diameters of over 30 mm. The thickness of the common wall between two contiguous corallites ranges from 1 to 1.25 mm.

The septa are crowded, and of two orders, sixty to sixty-five of each at diameters of 35 to 45 mm, and forty to forty-six at diameters of 18 to 20 mm. The septa are somewhat thickened in the tabularium and the thickening increases outwards so that neighbouring major and minor septa are contiguous in the dissepimentarium, where however, their vertical continuity is broken by large, inclined, elongate lonsdaleoid dissepiments, which are arranged in two or three vertical series, not regularly, but with interspersed smaller, elongate dissepiments.

The major septa are very long, reaching almost to the axis; in the tabularium they may all curve convolutely; in other corallites they may be grouped in irregular groups. A cardinal fossula is commonly plainly marked, bounded by the septa neighbouring a short cardinal septum and is slightly expanded inwards but almost closed at its axial end. The counter septum may be distinguished by its neighbouring minor septa being longer than the other minor septa. The minor septa may be contratingent; they may extend halfway across the zone of periaxial tabellae but in some corallites may be shorter.

The microstructure of the septa is somewhat obscured by recrystallisation; they show a median dark line in those parts within the tabularium; but in those parts based on the lonsdaleoid dissepiments the crystalline needles of $CaCO_3$ are less regularly pinnately arranged; as seen in radial longitudinal section of the dissepimentarium, the 'fibres' of the septa form large contiguous trabeculae that vary in width up to 12 in 2.5 mm; in some of these there appears to be a grouping of the fibres into 'tufts' in which the axial fibres are longer than the peripheral ones; the recrystallisation however leaves some doubt as to whether these tufts might not be second order trabeculae each with its own axis of divergence for its fibres. The orientation of the trabeculae in the discontinuous pieces of the septa based on the dissepiments is perpendicular to the curvature of the dissepiments.

The axial tabellae are flat-topped domes that may sag a little axially, when they may be reinforced by an irregular peripheral ring of smaller tabellae. They tend to be arranged in groups in which tabellae of smaller diameter lie with their outer edges abutting on tabellae of larger diameters. The periaxial tabellae are irregularly spaced, less numerous than the periaxial tabellae, and either flat or concave.

Remarks: In its growth form *E. banksi* resembles *E. abditum* and *E. yunnanense* rather than *E. bowerbanki*, being subcerioid to cerioid. The 'colony' from the Middle Devonian of Poshi, Yunnan, called *Sinospongophyllum planotabulatum* Yoh by Fontaine (1966, pl. 1, fig. 1) looks externally quite like our species, but Fontaine in his description implies that it is an association of solitary individuals with occasional offsets rather than a real colony.

The Tasmanian species differs from *E. bowerbanki, E. yunnanense* and *E. abditum* in having, in adult corallites between 30 and 40 mm in diameter, twice as many septa as the first two, and one and a half times as many as the third. Its septa are uniformly longer and more thickened than in the solitary corals referred by Fontaine (1966) to *Sinospongophyllum*.

The astraeoid *E. prantli* (Zheltonogova *in* Zheltonogova & Ivaniya, 1961) from the 'Lower Eifelian' Salairka beds (either Upper Emsian or Lower Couvinian, of the Salair, Siberia, has a wide tabularium like that of *Endophyllum*, rather than a very narrow one like that of *Iowaphyllum johanni* (Hall & Whifield, 1872, from the Frasnian [Cerro Gordo Member, Lime Creek Formation], of Hackberry Grove, Iowa, U.S.A.), the type species of *Iowaphyllum* Stumm (1949), to which genus Zheltonogova referred it. Its other characters are endophylloid. For a tabularium of 13 mm diameter ,it has only half the number of septa that *E. banksi* has, but the skeletal thickening is similar in the two species.

Phillipsastrea cuncta Pocta, 1902, which Prantl (1951, p. 11, pl. 4, figs 1, 2) transferred to *Iowaphyllum*, resembles *E. banksi* in the arrangement of its thickened septa and long lonsdaleoid dissepiments, but is described as thamnasterioid to subaphroid, with narrow tabularium (4-7 mm) and only eighteen septa of each order. The monotype is from the Slivenec Limestone of Koneprusy, Czechoslovakia, now (Pribyl & Vanek, 1968) regarded as Lower Pragian (Upper Siegenian). It should be re-investigated for possible relationship to *Endophyllum*.

Suborder Cystiphyllina Nicholson *in* Nicholson & Lydekker, 1859

Family TRYPLASMATIDAE Etheridge, 1907

Genus **TRYPLASMA** Lonsdale, 1845

Tryplasma spp.

Plate 3, figs 3-6

Tryplasma is represented in the fauna by twenty-two fragments of solitary coralla. Nineteen are from cylindrical corallites showing repeated rejuvenescence and are up to 12 mm in diameter. The rejuvenescence rings usually parallel one another and represent constrictions in the corallite diameter of less than 1 mm. They contain fifty-eight to seventy-two septa. The major septa are up to 2.5 mm in length and commonly only slightly longer than the minor septa. The septa project from a narrow stereozone and are spinose and rhabdacanthine. The trabeculae are straight and are commonly inclined upwards and inwards; however in parts of some corallites, especially before rejuvenescence, they tend to be almost horizontal. The tabulae are complete and slightly domed to concave; periodically they are thickened and then usually carry short trabeculae. These specimens show some similarity to *T. columnare* Etheridge, 1907, from the Siegenian? to Emsian Garra Formation of New South Wales but the material is not sufficient for precise identification.

Three specimens UTGD 51635, 51664, 51716 are trochoid with strong oblique rejuvenescence. They show numerous epithecal scales arranged in chevrons parallel to the rugae. They contain seventy-eight to eighty-two rhabdacanthine septa, the rhabdacanths projecting inwards and upwards from a narrow stereozone. The minor septa are half as long as the major septa. The tabulae are widely spaced and horizontal. In their shape, short minor septa and flat tabulae, these specimens resemble *T. wellingtonense* Etheridge, 1895, also from the Garra Formation.

Family GONIOPHYLLIDAE Edwards & Haime, 1850

Genus **RHIZOPHYLLUM** Lindström, 1866

Rhizophyllum enorme Etheridge, 1903

Plate 3, figs 1, 2

Rhizophyllum enorme Etheridge, 1903, p. 232, pl. 47, figs 1-7; Hill & Jones, 1940, p. 182, pl. 2, figs 3, 4.

Rhizophyllum cf. *enorme*; Hill, 1942a, p. 15, pl. 1, fig. 4.

Rhizophyllum uralicum Soshkina, 1949, p. 56, pl. 11, fig. 1; 1952, p. 176, pl. 10, fig. 40.

Rhizophyllum enorme; Bulvanker 1958, p. 46, pl. 17, fig. 1; Zheltonogova & Ivaniya, 1961, p. 393, pl. D47, fig. 2.

Type specimens: Two specimens AM F45944, F45945 from Boree Creek, portion 3, parish Cudal, county Ashburnham, near Molong, central New South Wales; Garra Formation, Siegenian? to Emsian.

Diagnosis: Large, solitary *Rhizophyllum* with septa well developed although commonly discontinuous in part on the flat counter side and with narrow stereozone on the curved side.

Description of Tasmanian material: The five corallites are solitary, calceoloid, suberect, and slightly curved in the counter-cardinal plane in their young stages. The apical angle varies from 45° to 60°. The largest is about 95 mm in height measured from the apex to the calicular lip on the flattened side; its maximum diameter is 70 mm and thickness measured at right angles is 33 mm. The exterior shows repeated rejuvenescence involving only small contractions of the diameter with the contractions, which are most noticeable on the flat side, never more than 5 mm. Rootlets up to 2.5 mm in diameter project from the rejuvenescence rings on the flat surface at or near its angle with the curved surface. The epitheca is almost entirely removed but where present, usually in the grooves of rejuvenescences, it is thin and shows fine growth rings, narrow septal furrows and broad longitudinal interseptal ridges. A broad ridge external to the counter septum divides the flat side longitudinally. The calice is deep, and steeply tilted down from the flat side. The calicular floor slopes moderately steeply away from a flat or slightly everted calicular platform on the flat side towards a deep sub-semicircular trough immediately inside the narrow steeply inclined calicular lip on the curved side. This trough deepens sharply in the counter cardinal plane. The calicular platform on the flat side exhibits radial ridges and a deep median pit in the large specimen and a prominent tooth in the smallest specimen.

In transverse section the corallum is semicircular with septa developed along the straight side. On this flat side the median (counter) septum is usually swollen laterally; it is the longest of the septa in sections through the young parts of the corallites and in the small specimen; however in calicular sections of the larger specimens it is considerably shorter than the adjacent septa which may be up to a quarter of the width of the corallite in length. The septa shorten gradually towards the angles where it is thought but not proved, that the alar fossulae are developed. In calicular sections a narrow stereozone is developed at the inner edges of the septa by the fusion of adjacent septa. In the calicular section of the largest corallite there are twenty-five septa on either side of the counter septum. Major and minor septa cannot be distinguished with certainty. In places the septa are discontinuous and represented by one or perhaps several rows of small corn-like projections on the dissepiments. On the curved side, there is a narrow stereozone, in which radial elements are sometimes distinguishable. The fossula is excentric, lying adjacent to the centre of the curved surface and is elongate in the counter-cardinal plane.

In longitudinal section through the fossula the lumen is filled with large skeletal elements sloping down towards the deep fossula. They are differentiated into elongate dissepiments and horizontal to concave tabellae. The dissepiments on the counter side are horizontally based near

the periphery but increase in inclination towards the axis. Those on the cardinal side are steeply inclined. The tabularial floors are flat to concave. The boundary between tabularium and dissepimentarium is quite marked on the cardinal side but the two zones merge on the counter side. Periodic thickening of certain successive calicular floors or parts of floors give close, narrow stereocones corresponding probably with the rejuvenescence rings.

Remarks: The larger specimens from Point Hibbs resemble *R. enorme* from the Upper Siegenian? to Emsian Garra Formation, New South Wales, in all respects except that stereocones are more frequently developed, the peripheral stereozone on the curved side is slightly thicker, and the tabellae less globose; all these differences are of degree and in our opinion within the limits of intraspecific variation. The smallest specimen has a very acute apex and then expands rapidly so that the corallum appears flared; in section it is similar to the early stages of the larger specimens. It is considered a young form. Specimens from the Garra Formation show rapid but less marked expansion in the early stages of growth.

Tasmanian specimens are distinguished from the Wenlockian *R. sinense* Lindström, 1883b (see Hill & Jell, 1969) by their more complete septa and larger dissepiments and tabellae. They differ from *R. ukalundense* Jell & Hill, 1969 from the Emsian or more probably early Couvinian of Ukalunda, north Queensland, in their narrower and more poorly developed peripheral stereozones.

The only other recorded occurrence in Australia is one specimen referred to *R.* cf. *enorme* by Hill (1942a, pl. 1 fig. 4) from the Emsian Mt Etna Limestone, central Queensland.

Family PLASMOPHYLLIDAE Dybowski, 1873

Genus **PLASMOPHYLLUM** Dybowski, 1873

Subgenus **Plasmophyllum (Plasmophyllum)** Dybowski, 1873

Type species, synonymy and discussion: See Birenheide (1964) and Jell & Hill (1969, p. 15).

Distribution: Lower and Middle Devonian, cosmopolitan.

Plasmophyllum (*Plasmophyllum*) *tasmaniense* sp. nov.

Plate 3, figs 7-13

Holotype: UTGD 52054, Point Hibbs Limestone, Point Hibbs, western Tasmania; Emsian?

Diagnosis: Solitary *P.* (*Plasmophyllum*) with inversely and obliquely conical calicular floors deepest at the cardinal fossula at the outer edge of the tabularium, expanding slightly into a shallow subquadrate counter-cardinal trough and then rising more steeply towards the calicular edge. Skeletal thickening variable, greatest in early stages and in cardinal quadrants, and in adult stages commonly confined to distant calicular floors (in 'septal cones'). Septa numerous and long, represented by thorn-like trabeculae, in contact in the thickened zones, isolated elsewhere.

Description: The corallum is solitary, ranging from sub-erect to slightly and irregularly curved, commonly with rejuvenescence. The longest fragment is 80 mm, and the maximum diameter observed is 40 mm. Many corallites grow no wider than 17 to 20 mm, and there are several smaller individuals. Externally the corallites show longitudinal ridges of uniform width and narrower furrows. One specimen (pl. 3, fig. 13) shows epithecal scales arranged in chevrons.

The septa are very numerous; at a diameter of 24 mm UTGD 51656 showed forty-nine long major septa and forty-nine slightly thinner and shorter minor septa, countable because their peripheral bases were all clearly preserved in the transverse section. At a diameter of 36 mm the holotype has approximately fifty-seven of each order. Each septum is represented by a radial longitudinal row of thorn-like trabeculae contiguous where skeletal thickening occurs, but isolated elsewhere. The trabeculae are perpendicular to the curvature of the dissepiments on which they are based or through which they pass; those based on tabulae are perpendicular to the curvature of the tabulae, and their radial arrangement is less regular than it is in the dissepimentarium. The trabeculae may pierce the horizontal skeletal elements of two or more successive calicular floors; or they may be discontinuous below such floors, appearing as small corns on the horizontal skeletal elements. Within each septum, there may be on the average four trabeculae in 2.5 mm measured perpendicular to their length. The microstructure of the trabeculae has been affected by recrystallisation but traces of groupings of their fibres are visible in some (pl. 3, figs 7f, g), indicating that they were either rhabdacanths or, less probably, tufted monacanths. Growth lamellation has been emphasised in their basal parts (pl. 3, fig. 8d). In some places the trabeculae appear to be simple monacanths.

A cardinal fossula is present, almost at the periphery in young forms without dissepimentarium, and immediately after rejuvenescence, but lies at the outer margin of the tabularium in adult stages with a dissepimentarium.

The dissepimentarium is moderately wide; the dissepiments are steeply inclined on the cardinal side, less so in the counter and alar sectors. They are long, broad plates weakly convex upwards and inwards, supplemented by smaller, similar plates. The tabularial floors are broad and flat to shallowly concave, the deepest part being in the cardinal fossula; from the fossula there extends in the tabularial floors of most individuals, a subquadrate, shallower depression, the longer axis of which lies in the counter-cardinal plane; the tabulae and auxiliary tabellae then slope upwards and outwards to merge in the counter and alar sectors with the dissepiments.

Skeletal thickening is variable. In many specimens it is very great in young stages, and extends quite far up into the later stages in some. It is greater in the cardinal quadrants than in the counter quadrants; in some specimens the more delicate tissue of the counter quadrants has broken away. In most corallites periodic thickening affects the later stages in 'septal cones'. All the horizontal skeletal elements corresponding with a particular calicular floor are thickened, and diagenesis has emphasised the growth lamellation

so that the sclerenchyme appears lamellar rather than fibrous. Thickened trabeculae arise from these thickened dissepiments or tabulae; their bases appear not quite in contact, being separated by lamellar sclerenchyme. In many transverse sections the thickening outlines the shallow broad subquadrate counter-cardinal trough in the tabularium.

Remarks: The epithecal scales of *P.* (*P.*) *tasmaniense* are like those described for *Tryplasma tubulatum* (Schlotheim) by Lindström (1883a), for *Chavsakia chavsakiensis* Lavrusevich (1959) and for *Holmophyllum squamosum* Lavrusevich (1960).

Due to the deepest part of the calicular floor being at the cardinal fossula, and to the presence of a broad shallow trough in the counter-cardinal plane, the calicular floors and 'septal cones' of thickening appear excentric and oblique but subsymmetrical. Differences in the obliquity of both transverse and longitudinal sections result in different patterns, and the orientation of all thin sections must be carefully noted; without careful study their appearance may be so different as to suggest different species.

The range and type of variation is that seen in *Plasmophyllum* (*Plasmophyllum*) Dybowski, so admirably analysed by Birenheide (1964), and we have therefore placed our species in this genus. The presence of rhabdacanthine or at least of tufted monacanthine trabeculae has however not been noted in the German Middle Devonian species described by Birenheide.

The taxonomic value of rhabdacanthine trabeculae requires critical evaluation. Among the Silurian cystimorphs, *Holmophyllum* Wedekind, 1927 (type species *H. holmi* Wedekind, 1927, p. 31, pl. 4, figs 6-8, from the Eke Marls?, Lower Ludlovian, of Lau-backar, Gotland) has large isolated trabeculae that are rhabdacanths, though these are never seen to be immersed in lamellar sclerenchyme as in a typical solitary tryplasmid. Its septa are withdrawn to the dissepimentarium, leaving a tabularium with concave to flat tabularial floors; the dissepimentarium contains both large and small dissepiments, unthickened in the holotype. The thin transverse section of the holotype is figured herein (pl. 4, fig. 6) and clearly shows that the fibres of the trabeculae are grouped into rod-like second order trabeculae. *Mazaphyllum* Crook (1955) from the Silurian of New South Wales (type species *M. cortisjonesi* Crook, 1955, p. 1053, text-figs 2, 3) is thamnasterioid with horizontal skeletal elements like those of *Holmophyllum*, with long rhabdacanthine and also some holacanthine? trabeculae. *Hedstroemophyllum* Wedekind, 1927 (type species *H. articulatum* Wedekind, 1927, p. 65, pl. 21, figs 1, 2, from the Wenlockian of the northwest coast of Gotland), has long isolated monacanthine trabeculae in some of which the fibres appear grouped in tufts rather than in second order trabeculae; the junction of dissepimentarium and tabularium is less sharply marked than in *Holmophyllum*, and the tabularial floors are inversely concave with an occasional large convex plate. Two thin sections of a paratype are illustrated herein (pl. 4, fig. 3). *Hedstroemophyllum* seems morphologically intermediate between *Cystiphyllum* Lonsdale, 1839 (type species *C. siluriense* Lonsdale, 1839, pl. 16 *bis*, figs 1, 1a, Wenlock Limestone, Dudley, England, longitudinal section of its holotype figured herein (pl. 4, fig. 8)) and *Gyalophyllum* Wedekind, 1927 (type species *G. angelini* Wedekind, 1927, p. 64, pl. 19, figs 1, 2, basal Ludlovian Klintberg Group, Klintberg, Gotland, thin sections of holotype figured herein (pl. 4, fig. 1)). In the holotype of *C. siluriense* the trabeculae are very short and slender, set in the rather slight skeletal thickening on certain of the calicular floors. In *G. angelini* the trabeculae are long and contiguous in each radial longitudinal row, and are rhabdacanths, not, apparently, immersed in lamellar sclerenchyme.

In view of Birenheide's conclusions on the Devonian cystimorphs, it seems not unlikely that some of these four genera may prove to be synonymous, when full-scale studies are undertaken on them. Another genus that should be considered in this connection is *Lamprophyllum* Wedekind, 1927 (type species *L. degeeri* Wedekind, 1927, p. 78, pl. 27, figs 1-4, from the [Hemse Group, Ludlovian] marls of Petesvik, Gotland). Thin sections of the holotype are figured herein (pl. 4, fig. 2). It has short major septa, degenerate minor septa, a wide tabularium of flat tabellae, and numerous series of small dissepiments, and may bear the relation to the Silurian cystimorphs that the septate *Plasmophyllum* (*Mesophyllum*) does to the other Middle Devonian cystimorphs. *Stortophyllum* Wedekind, 1927 (type species *S. simplex* Wedekind, 1927, p. 31, pl. 4, fig 1, Ludlovian Eke marls of Lau-backar, Gotland) has rhabdacanths as in *Tryplasma*. The thin section of the holotype is figured reversed herein (pl. 4, fig. 5).

None of the Eurasian Ludlovian, Skalian or Gedinnian species so far referred in the literature to *Holmophyllum*, *Hedstromophyllum*, *Gyalophyllum* or *Lamprophyllum* resemble our species; nor do any of the Eurasian Skalian or Lower or Middle Devonian cystimorphs referable to *Nataliella* Sytova, *Thecaspinellum* Nikolaeva (and its possible synonym *Chavsakia*), or to the protean genus *Plasmophyllum*. None of the Silurian or Devonian cystimorphs of eastern North America described by Stumm (1965) are at all closely comparable with our new species.

Order TABULATA Edwards & Haime, 1850

Superfamily *FAVOSITOIDEA* Dana, 1846

Family FAVOSITIDAE Dana, 1846

Genus **FAVOSITES** Lamarck, 1816

Favosites goldfussi d'Orbigny, 1850

Plate 5, figs 1-3

Favosites gothlandica Goldfuss, 1826, *pars*, p. 78, pl. 26, fig. 3b only.

Favosites goldfussi d'Orbigny, 1850, *pars*, p. 107; Jones, 1936, p. 19, pl. 2, figs 8-10; Philip, 1962, p. 142, pl. 11, figs 6-9, *quo vide for* discussion of Australian occurrences.

Description of Tasmanian material: The fifteen coralla are commonly pyriform or small subhemispherical colonies up to 5 cm in diameter. One, UTGD 51790, is a fragment of a larger colony and measures 8 mm in height and 4 mm by 7 mm across. Adult corallites are five- to seven-sided and their

mean diameter within a corallum varies from 2.3 to 2.7 mm. Young corallites are triangular to quadrate in cross section and usually originate in the corners of the parent corallites; the wall is inserted very soon after their origin. The walls are straight as seen in transverse section but somewhat irregular in vertical section. They are 0.12 to 0.2 mm in thickness and show a median dark plane in transmitted light with fibres normal to it on either side; growth lines subparallel to the median plane can occasionally be traced across the fibres. Bundles of the fibres become elongated into spines. The spines are 0.2 mm at their base, taper axially, and project up to 0.35 mm into the lumen; they are nearly horizontal or are inclined upwards and inwards at less than 20° to the horizontal, and are sometimes slightly curved. They may be arranged in as many as seven irregular alternating rows on each face. The mural pores are round, 0.14 to 0.23 mm in diameter, and are arranged in two alternating rows or occasionally in a single irregular row. They are often closed by a thin diaphragm in the plane of the mid-line of the walls. The tabulae are thin, complete and horizontal with five to ten per 5 mm.

Remarks: In growth form, size and internal structure, the Point Hibbs material shows more similarity to the specimens referred to *F. goldfussi* from the Couvinian of Belgium by Lecompte (1939, pl. 13, figs 1-13; pl. 14, figs 1, 2), than to the other Australian specimens referred to that species. The smaller pyriform colonies resemble Lecompte's *F. goldfussi* forma *pyriformis* and the larger discoidal to subhemispherical type, his *F. goldfussi* forma *regularis*. Jones (1936) noted that a similar variation in growth form was shown by *F. goldfussi* from the Eifelian of the Eifel; he regarded the small pyriform coralla previously referred to *F. forbsi* var. *eifelensis* Nicholson as young forms of *F. goldfussi*. The lectotype of *F. goldfussi* (chosen by Jones, 1936, p. 20) from the *Calceola*-Schichten, Middle Devonian of Germany, is of the small pyriform type; its internal structure has not been illustrated. In the Tasmanian forms the tabulae are more widely spaced than in the Belgian specimens (ten to twenty against thirty to fifty per 10 mm), and sometimes there is only a single row of mural pores on the corallite face. *Favosites saginatus* Lecompte, 1939, p. 94, pl. 14, figs 8-14, from the Couvinian of Belgium is similar to the Point Hibbs *F. goldfussi* in corallite size and spacing of tabulae but differs in having much thicker walls; its septa are commonly stouter and more prominent.

Favosites careyi sp. nov.

Plate 5, figs 4, 5

Named in honour of Professor S. W. Carey, Geology Department of the University of Tasmania

Holotype: UTGD 51781 from the Point Hibbs Limestone, Sanctuary Bay, Point Hibbs, western Tasmania; Lower Devonian. Three paratypes.

Diagnosis: Thin-walled, regularly polygonal, large corallites (mean adult diameter 3.0 to 3.8 mm); short extremely thin septal spines are developed sparsely; mural pores small (0.08 to 0.2 mm), arranged in three to five alternating vertical series. Tabulae complete, commonly horizontal and distant.

Description: All the specimens are fragments of large massive coralla; the largest is 5 x 12 cm across and 12 cm high. The adult corallites are polygonal, five- to seven-sided, and are relatively large, from 2.6 to 4.8 mm in diameter; the means of the four coralla vary from 3.05 to 3.8 mm. The walls are straight and show a median dark line in transmitted light, with fibres normal to it on either side. They are straight or rarely slightly wavy in transverse section and are relatively thin (0.1 to 0.25 mm). Increase is peripheral and non-parricidal with the wall separating the offset usually based on a tabula.

Septa poorly developed, consisting of rare septal spines which are short, extremely slender projections from the wall and are almost horizontal. The mural pores are round, small (0.08 to 0.2 mm in diameter) and are arranged in three to five alternating vertical rows on each face of the corallites; there may be three in a horizontal row (pl. 5, fig. 4b). Those in the one vertical row are 0.5 to 0.8 mm apart. The tabulae are complete, horizontal or slightly arched and distant, 0.6 to 1 mm apart.

Comparison: Of the Australian *Favosites*, *F. careyi* resembles *F. richardsi* Jones, 1937, pp. 89-90, pl. 12, figs 2, 3 from the Silurian (Ludlovian?) Barrandella Shales, Hattons Corner, Yass New South Wales, in corallite size, tabular spacing, and the arrangement of mural pores in three or more rows. It differs however in the more polygonal nature of the corallites, scarcity of septal spines which are more slender, and smaller mural pores. The specimen referred to F. *richardsi* by Jones, 1944, p. 35, pl. 1, figs 5, 6 from the Upper Silurian of the Wellington district, New South Wales differs from the new species in that the corallites are nearly round, contain more numerous spines and have only two rows of pores on each face.

The arrangement and small size of the mural pores, scarcity of septal spines, regular polygonal form of the corallites and the thin walls of *F. careyi* distinguish it from all other species of *Favosites* with similar sized corallites. It shows most resemblance to *F. shirdagicus* Kim, 1966, p. 36, pl. 22, fig. 1 from the 'Lower Eifelian' (either Upper Emsian or Lower Couvinian) zone of *Favosites regularissimus* Yanet, Mt Raykazak southwestern part of Zarafshan Range, Central Asia. *F. careyi* has more numerous and smaller (0.1 to 0.25 mm compared with 0.25-0.35 x 0.45-0.55 mm) mural pores, less well developed septal apparatus, and polygonal five- to six-sided corallites as opposed to the more rounded eight- to nine-sided corallites of *F. shirdagicus*.

Genus **SQUAMEOFAVOSITES** Chernyshev, 1941

Type species, diagnosis and distribution: See Jell & Hill (1969).

Squameofavosites bryani (Jones, 1937)

Plate 5, figs 6, 7

Favosites bryani Jones, 1937, p. 96, pl. 15, figs 3-6.
Favosites ?bryani; Hill, 1942b, pl. 2, fig. 6.
Squameofavosites bryani; Jell & Hill, 1969, p. 21, pl. 7, figs 2, 3.
Holotype, diagnosis and distribution: See Jell & Hill (1969).

Description: The thirty coralla are flattened hemispherical to cake-like colonies varying in diameter from 2 to 11 cm. The corallites are of moderate size, average diameter 1.05 mm; within a corallum the corallites are of uniform size but there is a considerable range (0.82 to 1.23 mm) in the mean between coralla. The adult corallites are four-to seven-sided, the sides are straight or rarely slightly curved. Increase is peripheral, non-parricidal. In transverse section the parent is elongated immediately prior to budding and the dividing wall is then inserted usually developing from the free edge of a squamula (pl. 5, fig 6d). The offsets are quadrate. The corallite walls are straight and commonly moderately thick, 0.1 to 0.16 mm, but in other parts of a corallum may be as thin as 0.06 mm. The mural pores are round or suboval, large (0.2 to 0.35 mm in diameter), closely spaced (centres 0.6 mm apart), and arranged in a single median row or rarely two subalternating rows on each face. Above and occasionally below the mural pores, squamulae project up to 0.35 mm into the lumen as eaves-like platforms. They are 0.3 mm wide and 0.03 mm thick at their base and taper axially. They are typically horizontal or slightly inclined upwards. Small short spines are sometimes developed on the wall alongside the mural pores. The tabulae are flat, horizontal and complete; they may be suspended from the free edges of squamulae. Zones in which the tabulae are closely spaced (up to twenty per 5 mm) alternate with zones in which they are distant (six per 5 mm).

Remarks: The Point Hibbs specimens do not differ significantly in internal structure from the holotype of *S. bryani* from the Cavan Bluff Limestone of Taemas. However their mean corallite diameter (0.83 to 1.23 mm mean 1.05 mm) is less than that of the holotype (1.27 mm) but is within the range of other specimens of *S. bryani* from Taemas. The mean corallite diameters of two topotypes (UQF 53136, 53137) are 1.20 and 0.99 mm respectively. The paratypes of Jones (1937) have means of 1.39 and 1.42 mm; corallites of specimens from the *Receptaculites* limestone of Taemas vary from 1.4 to 1.7 mm. Philip (1962) admitted a range of 0.8 to 1.5 mm in *Favosites squamuliferus* forma *bryani* Jones (forma∝).

Squameofavosites bryani var. *ramosus* var. nov.

Plate 6, fig. 4

Figured specimen: UTGD 51745 from Point Hibbs Limestone, Point Hibbs, Tasmania.

Description: The specimen is a worn flat colony 8 cm in diameter and 2.5 mm thick. It consists of a compact mass of finger-like branches each approximately 1 cm in diameter diverging from the centre of one edge. The branches are for the most part cylindrical, horizontal, bifurcating and intertwining in the horizontal plane; they periodically give off vertical branches which are commonly intergrown. The corallites parallel the axis in the central part of the branches but curve to open normal to the surface. Their diameter varies from 0.8 to 1.5 mm (mean 1.17 mm). The common wall is variable in thickness (0.08 to 0.3 mm). Short septal spines project upwards and inwards and are approximately 0.14 mm in diameter at their base. Above the mural pores squamulae are commonly developed. The mural pores are round or slightly ovate vertically; they are commonly 0.2 to 0.25 mm in diameter and arranged in a single row. The tabulae are unevenly spaced, five to twelve per 5 mm. They are commonly complete but in places are incomplete. As seen in longitudinal section, they are sometimes grouped at or near a mural pore. Occasionally a tabula does not span the lumen nor join with other tabulae but is based like a bubble on the wall. In longitudinal section such a tabula appears circular or parabolic.

Remarks: This form resembles typical *S. bryani* in all characters except growth habit and the occasional irregularity of the tabularium; we regard it as a growth form of that species.

In growth habit it shows a closer similarity to *Rudakites multiformis* Leleshus, 1964, p. 47, pl. 4, figs 1-4, the type species of that genus, from the 'Hercynian limestones' late Lower Devonian (Coblenzian Stage) of the northern slopes of the Zeravshan Ranges, left side of the Shishkat Gorge (right tributary of the River Kshtut) Central Tadzhikistan, U.S.S.R., than to any *Favosites*. The corallite walls in *R. multiformis* are thickened near the surface so that *Rudakites* is grouped with the Thamnoporidae; the Tasmanian specimen does not show any thickening.

Family PACHYPORIDAE Gerth, 1921

Genus **CLADOPORA** Hall, 1851

Cladopora sp.

Plate 6, figs 1-3

Description: The numerous fragments, mostly weathered, are of cylindrical branchlets, straight or slightly flexuous, with diameter ranging from 1.125 to 4 mm approximately, except for one larger branch (UTGD 52157, pl. 6, fig. 2) which shows repeated one-sided dichotomy and has a diameter of 5 to 6 mm, expanding a little just below a dichotomy; one branchlet shows very rapid tapering to a blunt point. The corallites open obliquely, and are arranged not very regularly in longitudinal rows, those of neighbouring rows alternating. Most of the branches are worn, but in the large branch (UTGD 52157) some show slightly projecting crescentic lower lips; the median pits in the calices are subcircular.

In their tangential section the calices are seen to be polygonal to subpolygonal-rounded, the lower lip being the more rounded, or crescentic; the diameter from median dark line to median dark line (angle to angle) is about 0.375 mm in large calices and the rounded axial pit is 0.25 mm or somewhat narrower; common walls between these pits range from 0.175 to 0.35 mm in thickness. Their walls are only slightly thickened. In the axial region of the branch the diameter of corallites ranges up to 0.175 or even 0.25 mm and they grow vertically for a short distance. As the corallites diverge to open at the periphery at an angle of about 40°, both diameter and wall thickening gradually increase. Sparse tabulae are present, but septal spines are not certainly observed. Mural pores are sparse and small (0.05 to 0.10 mm) in the axial parts of the branch, but have not been

observed in the peripheral zone of greater skeletal thickening.

Remarks: No tabulae are reported by Oliver (1963) in the type material of the type species *Cladopora seriata* Hall, which is somewhat less thickened than our material.

The Tasmanian material may prove conspecific with that described as *Cladopora* sp. by Jell & Hill, 1969 from the Ukalunda Beds of north Queensland. It is also comparable with *Cladopora gippslandica* Chapman as figured by Philip (1962, pl. 18, figs 1, 6, 7) from the Gedinnian [?] Boola Beds, Tyers River area, Victoria. However Chapman (1907) described his type specimens as having calicular openings taller than wide. In the Tasmanian material the median pits of the calices are subrounded.

It is possible that all three forms are *Thamnopora*, but fragments of slender branches of similar type are currently referred to *Cladopora* in the absence of a critical investigation of the relations between *Cladopora* and *Thamnopora*.

Superfamily *SYRINGOPOROIDEA* Nicholson, 1879

Family NEOROEMERIIDAE Radugin, 1938

Genus **THECOSTEGITES** Edwards & Haime, 1849, p. 261

Type species, synonymy, diagnosis, discussion and distribution: See Hill & Jell (1970a).

Thecostegites ejuncidus sp. nov.

Plate 6, fig. 5

Latin, *ejuncidus*—slender, rush-like.

Holotype: UTGD 51744, Sanctuary Bay,. Point Hibbs, Tasmania; Point Hibbs Limestone, Emsian?. One paratype.

Diagnosis: *Thecostegites* with long, slender, closely spaced corallites and lateral expansions; with few septal spinules and numerous thin tabulae.

Description: The holotype is a subglobular corallum about 70 mm tall and 85 mm in diameter, broken at the base. The paratype is a very small fragment encrusting an alga?.

The corallites range in diameter from 0.625 to 1.0 mm, a common reading being 0.875 mm; they are long and straight, the longest observed extending through 15 mm of the corallum; this was not necessarily the total length of corallite, for the plane of section was not necessarily truly longitudinal; also stylolitic planes parallel to the lateral expansions are present causing horizontal discontinuities in parts of the corallum. The corallites are not perfectly cylindrical, their diameter expanding very slightly towards the ring of mural pores at each lateral expansion, contracting again between rings. The corallites may be contiguous or almost contiguous, and are only seldom separated by a distance as great as their diameter.

Septal spinules are sporadically developed in radial longitudinal series, projecting inwards from the peripheral stereozone, and a few are based on tabulae.

The tabulae are very thin, numerous, commonly complete and either subhorizontal or slightly concave; in places they may be incomplete, and grouped, forming very short excentric axial tubes in the corallites. Mural pores are numerous, arranged in close rings, and opening into the narrow transverse expansions that unite the corallites. Tabulae may continue from the corallites into these expansions. Each corallite has a peripheral stereozone about 0.125 mm thick, and this is continuous along both lower and upper surfaces of the expansions.

The expansions range in thickness from 0.25 mm (when the upper and lower stereozones are almost contiguous) to 0.625 mm; distance between expansions is commonly less than their thickness.

Remarks: *T. ejuncidus* differs from all previously described species of the genus in having more closely spaced and smaller corallites, with numerous tabulae and relatively sparse development of axial tubes, which remain short. Only *T. lepas* Sokolov (1952) from the central Russian upper Givetian has corallites of comparable diameter (0.8 to 0.9 mm as against 0.625 to 1.0 mm in the Australian species); *T. lepas* is readily distinguished by its short rare tubuli, its thinner walls (less than 0.1 mm) and the thickness of its connecting platforms which follow one another without intervening spaces, giving a compactness to the corallum, similar to that in *Neoroemeria*.

References

Birenheide, R., 1963.—*Cyathophyllum*- und *Dohmophyllum*-Arten (Rugosa) aus dem Mitteldevon der Eifel. *Senckenberg. leth.* 44 (5), 363-458, pls 46-62.

———, 1964.—Die 'Cystimorpha' (Rugosa) aus dem Eifeler Devon. *Abh. senckenb. naturforsch. Ges.* 507, 1-120, pls 1-28.

Bulvanker, E. Z., 1958.—*Devonskie chetyrekhluchevye korally okrain Kuznetzkogo basseyna.* 2 vols., 1-212, pls 1-93. Leningrad. (Vses. nauchno-issled. geol. inst.).

Chapman, F., 1907.—Newer Silurian fossils of eastern Victoria, Part I. *Rec. geol. Surv. Vict.* 2 (1), 67-80, pls 1-8.

———, 1914a.—Newer Silurian fossils of eastern Victoria, Part III. *Rec. geol. Surv. Vict.* 3, 301-316, pls 46-61.

———, 1914b.—Australasian fossils. 1-341. Melbourne.

Crook, K. A. W., 1955.—*Mazaphyllum*, a new cystiphyllid coral from the Silurian of New South Wales. *J. Paleont.* 29 (6), 1052-1056, text-figs 1-3.

Dubatolov, V. N., Chekhovich, V. D. & Yannet, F. E., 1968.—Tabulyaty pogranichnykh sloev silura i devona Altae-Sayanskoy gornoy oblasti i Urala. *In* Ivanovskiy, A. B. (Ed.) 1968. *Korally pogranichnykh sloev silura i devona Altae-Sayanskoy gornoy oblasti i Urala.* 5-170, pls 1-65. Nauka, Moscow.

Edwards, H. M. & Haime, J., 1851.—Monographie des polypiers Fossils des terrains palaeozoiques. *Arch. Mus. Hist. nat. Paris* 5, 1-502, pls 1-20.

———, 1853.—A monograph of the British fossil corals. Part IV. Corals from the Devonian Formation. *Palaeontogr. Soc.* [*Monogr.*], 211-244, pls 47-56.

Engel, G. & Schouppe, A. von, 1958.—Morphogenetisch-taxionomische Studie zu der devonischen Korallengruppe *Stringophyllum*, *Neospongophyllum* und *Grypophyllum*. *Paläont. Z.* 32, 67-114, pls 8, 9.

Etheridge, R., 1895.—An undescribed coral from the Wellington limestone, New South Wales. *Rec. geol. Surv. N.S.W.* 4, 160-162, pls 21, 22.

———, 1903.—An unusually large form of *Rhizophyllum*, lately discovered in New South Wales. *Rec. geol. Surv. N.S.W.* 7, 232, 233, pl. 47.

———, 1907.—A monograph of the Silurian and Devonian corals of New South Wales. Part II—The genus *Tryplasma*. *Mem. geol. Surv. N.S.W.* (*Palaeont.*) 13, 41-102, pls 10-28.

Fenton, C. L. & Fenton, M. A., 1924.—The stratigraphy and fauna of the Hackberry stage of the Upper Devonian. *Contr. Mus. Geol. Univ. Mich.* 1, 1-260, pls 1-45.

Fontaine, H., 1966.—Quelques Madréporaires dévoniens du Musée du Service Géologique de Saigon. *Archs géol. Viét-Nam* 9, 51-95, pls 1-16.

FROMENTEL, E. DE, 1861.—*Introduction a l'étude des polypiers fossiles.* 1-357. Paris.

GOLDFUSS, G. A., 1826-1833.—*Petrefacta Germaniae.* 1, 1-76, pls 1-25 (1826); 77-164, pls 26-50 (1829); 165-240, pls 51-71, (1831); 241-252, (1833). Düsseldorf.

GURICH, G., 1896.—Das Palaeozoicum im polnischen Mittlegebirge. *Zap. imp. miner Obshch.* (2) **32**, 1-539, pls 1-15.

HALL, J. & WHITFIELD, R. P., 1872.—Descriptions of new species of fossils from the Devonian rocks of Iowa. *23rd Ann. Rept New York State Cabinet Nat. Hist.*, 223-239, pls 9-12.

HALLER, W., 1936.—Einige biostratigraphische Untersuchungen in der Roher Mulde unter besonderer Berücksichtigung der Kerciphyllen. *Jb. preuss. geol. Landesanst. BergAkad.* **56**, 590-632, pls 32-43.

HILL, D., 1942a.—The Lower Devonian rugose corals from the Mt Etna Limestone, Queensland. *Proc. Roy. Soc. Qd* **54**, 13-22, pl. 1.

————, 1942b.—Some Tasmanian Palaeozoic corals. *Pap. Proc. Roy. Soc. Tasm.* 1941, 3-12, pl. 2.

————, 1950.—Middle Devonian corals from the Buchan district, Victoria. *Proc. Roy. Soc. Vict.* **62** (2), 137-164, pls 5-9.

————, 1954.—Devonian corals from Waratah Bay, Victoria. *Proc. Roy. Soc. Vict.* **66**, 105-118, pls 6-9.

———— & JELL, J. S., 1969.—On the rugose coral genera *Rhizophyllum* Lindström, *Platyphyllum* Lindström and *Calceola* Lamarck. *Neues Jb. Geol. Paläont.* (In press).

————————, 1970a.—The tabulate coral families Syringolitidae Hinde, Roemeriidae Pocta, Neoroemeriidae Radugin and Chonostegitidae Lecompte, and Australian species of *Roemeripora* Kraicz. *Proc. Roy. Soc. Vict.* (In press).

————————, 1970b.—Devonian corals from the Caning Basin, Western Australia. *Bull geol. Surv. West Aust.* **121** (In press).

HILL, D. & JONES, O. A., 1940.—The corals of the Garra Beds, Molong district, New South Wales. *J. Proc. Roy. Soc. N.S.W.* **74**, 175-208, pls 2-8.

————, PLAYFORD, G. & WOODS, J. T., 1967.—*Devonian fossils of Queensland.* 1-32, 15 pls. Qld Palaeontogr. Soc., Brisbane.

JELL, J. S. 1969.—Septal microstructure and classification of the Phillipsastareiclae. *In* Campbell, K. S. W. (Ed.) 1969. *Stratigraphy and Palaeontology: Essays in honour of Dorothy Hill.* 50-73, pls 7, 8. A.N.U. Press, Canberra.

————, & HILL, D., 1969.—Devonian corals from the Ukalunda district, North Queensland. *Publs geol. Surv. Qld* **340**, 1-27, pls 1-9.

———— & PEDDER, A. E. H., 1969.—*Martinophyllum*, a new genus of Devonian rugose corals. *J. Paleont.* **43** (3), 735-740, pls 95, 96.

JONES, O. A., 1929.—On the coral genera *Endophyllum* Edwards & Haime and *Spongophyllum* Edwards & Haime. *Geol. Mag.* **66**, 84-91, pl. 10.

————, 1936.—The controlling effect of environment upon the corallum in *Favosites*; with a revision of some massive species on this basis. *Ann. Mag. nat. Hist.* (*10*) **17**, 1-24, pls 1-3.

————, 1937.—The Australian massive species of the coral genus *Favosites*. *Rec. Aust. Mus.* **20** (2), 79-102, pls 11-16.

————, 1944.—Tabulata and Heliolitida from the Wellington district, N.S.W. *J. Proc. Roy. Soc. N.S.W.* **77**, 33-39, pl. 1.

KHALFIN, L. L. (Ed.), 1961.—Biostratigrafiya paleozoya Sayano-Altayskoy Gornoy oblasti, Tom II Sredniy Paleozoy. *Trudy sib. nauchno-issled. Inst. Geol. Geofiz.* (*miner.*) **20**, 1-850, pls S1-29, D1-105.

KIM, A. I., 1966.—Tabulyatomorfnye korally paleozoya Zaraf-shano-Gissarskoy gornoy oblasti. 1-17, pls 1-35. FAN, Tashkent. (Minist. geol. Uzbekskoy SSR).

LAMBE, L. M., 1901.—A revision of the genera and species of Canadian Palaeozoic corals. The Madreporaria Aporosa and the Madreporaria Rugosa. *Contr. Can. Palaeont.* **4** (2), 97-197, pls 1-18.

LANG, W. D. & SMITH, S., 1934.—Ludwig's 'Corallen aus Paläolithischen Formationen' and the genotype of *Disphyllum* de Fromentel. *Ann. Mag. nat. Hist* (*10*) **13**, 78-81.

————————, 1935.—*Cyathophyllum caespitosum* Goldfuss, and other Devonian corals considered in a revision of that species. *Q. Jl geol. Soc. Lond.* **91** (4), 538-590, pls 35-37.

LAVRUSEVICH, A. I., 1959.—Novyy rod *Chavsakia* iz ludlovskikh otlozheniy Zeravshano-Gissarskoy gornoy oblasti. *Izv. Akad. Nauk tadzhik. SSR* (*estest. Nauk*) (1959), **1** (28), 35-40, pls 1-3.

————————, 1960.—*Holmophyllum* s cheshuychatoy epitekoy iz silura Zeravshano-Gissarskoy gornoy oblasti. *Dokl. Akad. Nauk tadzhik. SSR* **3** (4), 21-26, pls 1, 2.

LECOMPTE, M., 1939.—Les Tabulés du Dévonien moyen et supérieur du bord sud du Bassin de Dinant. *Mem. Mus. r. Hist. nat Belg.* **90**, 1-229, pls 1-23.

LELESHUS, V. L., 1964.—Novyy devonskiy rod *Rudakites* (Tabulata) iz Tadzhikistanta. *Paleont. Zh.* 1964 (4), 45-48, pl. 4.

LINDSTROM, G., 1883a.—Om de Palaeozoiska formationernas operkelbärande koraller. *Bih. K. svenska VetensAkad. Handl.* **7**, (4), 1-112, pls 1-9.

————————, 1883b.—Obersilurische Korallen von Tshau-tiën im nordöstlichen Theil der Provinz Sz'-Tshwan. *In* RICHTHOFEN, F. VON, 1883. *Beitrage zur Pälaontologie von China*, IV. [Also issued as Band IV of RICHTHOFEN, F. VON, 1883. China]. 50-74, pls 5-7. Berlin.

LONSDALE, W., 1839.—Corals. *In* MURCHISON, R. I., 1839. *The Silurian System.* 675-694, pls 15, 15 *bis*, 16, 16 *bis*. London.

MANSUY, H., 1912.—Etude géologique du Yun-nan Oriental Ile Partie, Paleontologie. *Mém. Serv. geol. Indochine* **1** (2), 1-146, pls 1-25.

MCLAREN, D. J., 1964.—Corals of the Devonian Horn Plateau Formation. *Bull. geol. Surv. Can.* **114** (2), 3-28, pls 2-12.

OLIVER, W. A., 1963.—Redescription of three species of corals from the Lockport Dolomite in New York. *Prof. Pap. U.S. geol. Surv* **414-G**, G1-G9, pls 1-5.

————————, 1968.—Succession of rugose coral faunas in the Lower and Middle Devonian of eastern North America. *In* OSWALD, D. H. (Ed.), 1968. *International symposium on the Devonian System, Calgary*, 1967, *Vol.* 2. 733-744. Alberta Soc. Petrol. Geol., Calgary.

D'ORBIGNY, A., 1850.—*Prodrome de paléontologie stratigraphique universelle des animaux mollusques et rayonnés.* I, 1-394, Paris.

PHILIP, G. M., 1960.—The Middle Palaeozoic squamulate favositids of Victoria. *Palaeontology* **3** (2), 186-207, pls 30-34.

————————, 1962.—The palaeontology and stratigraphy of the Siluro-Devonian sediments of the Tyers area, Gippsland, Victoria. *Proc. Roy. Soc. Vict.* **75** (2), 123-246, pls 11-36.

———————— & PEDDER, A. E. H., 1968.—Stratigraphical correlation of the principal Devonian limestone sequences of eastern Australia. *In* OSWALD, D. H. (Ed.), 1968. *International symposium on the Devonian System, Calgary*, 1967, *Vol.* 2. 1025-1041. Alberta Soc. Petrol. Geol., Calgary.

POCTA, P., 1902.—Anthozoaires et Alcyonaires. *In* BARRANDE, J., 1902. *Systéme Silurien du centre de la Bohême*, 8 (2), 1-347, pls 20-117. Prague.

PRANTL, F., 1951.—On the supposed occurrence of the genus *Phillipsastrea* d'Orbigny, 1849, in the Devonian of Bohemia. *Sb. nar. Mus. Praze* (*B*) **7** (3) (Geol. Palaeont. 2), 3-17, pls 1-4.

PRIBYL, A. & VANEK, J., 1968.—Biostratigraphische Studie über die Fauna des Budnaniums bis Pragiums im Binblick auf die Grenze zwischen Silur und Devon im Barrandium und in den übrigen europaischen Gebieten. *Neues Jb. Geol. Paläont. Mh.* 1968 (7), 413-448.

ROMINGER, C., 1876.—*Lower Peninsula* 1873-1876. *Vol.* 3, *pt* 2, *Palaeontology. Fossil corals.* 1-161, pls 1-55, Geol. Surv. Michigan, New York.

SCHLUTER, C., 1885.—Ueber neue Korallen aus dem mitteldevon der Eifel. *Verh. naturh. Ver preuss. Rheinl.* **42**, 6-13 [Not seen].

————————, 1889.—Anthozoen des rheinischen Mittel-Devon. *Abh. preuss. geol. Landesanst.* **8** (4), 261-465, pls 1-16.

SCRUTTON, C. T., 1968.—Colonial Phillipsastraeidae from the Devonian of south-east Devon, England. *Bull. Br. Mus. nat. Hist.* (*Geol.*) **15** (5), 181-281, pls 1-18.

SMITH, S., 1945.—Upper Devonian corals of the Mackenzie River region, Canada. *Spec. Pap. geol. Soc. Am.* **59**, 1-126, pls 1-35.

SOKOLOV, B. S., 1952.—Tabulyaty paleozoya evropeyskoy chasti SSSR, Chasti IV, devon Russkoy platformy i Zapadnogo Urala. *Trudy vses. neft. nauchno-issled. geol.-razv. Inst.* (*new*) **62**, 1-291, pls 1-40.

SOSHKINA, E. D., 1949.—Devonskie korally Rugosa Urala. *Trudy. paleont. Inst.* **15** (4), 1-162, pls 1-58.

————————, 1952.—Opredelitel' devonskikh chetyrekhluchevykh korallov. *Trudy paleont Inst.* **39**, 1-178, pls 1-49.

STRUSZ, D. L., 1968.—Lower and Middle Devonian of the Molong Geanticline, New South Wales, Australia. *In* OSWALD, D. H. (Ed.), 1968. *International symposium on the Devonian System, Calgary*, 1967, *Vol.* 2. 123-133. Alberta Soc. Petrol. Geol., Calgary.

STUMM, E. C., 1949.—Revision of the families and genera of the Devonian tetracorals. *Mem. geol. Soc. Am.* **40**, 1-92, pls 1-25.

STUMM, E. C., 1965.—Silurian and Devonian corals of the Falls of the Ohio. *Mem. geol. Soc. Am.* **93**, 1-184, pls 1-80.

TALENT, J. A., 1965.—The stratigraphic and diastrophic evolution of central and eastern Victoria in the Middle Palaeozoic times. *Proc. Roy Soc. Vict.* **79** (1), 179-195.

———— & BANKS, M. R., 1968.—Devonian of Victoria and Tasmania. *In* OSWALD, D. H. (Ed.), 1968. *International symposium on the Devonian System, Calgary, 1967, Vol. 2.* 147-163. Alberta Soc. Petrol. Geol., Calgary.

VOLLBRECHT, E., 1926.—Die Digonophyllinae aus dem unteren Mittle-Devon der Eifel. *Neues Jb. Miner. Geol. Paläont. BeilBd.* **55** (B), 189-273, pls. 8-16.

WEDEKIND, R., 1927.—Die Zoantharia Rugosa von Gotland (bes. Nordgotland). *Sver geol. Unders. Afh.* (*Ca*) **19**, 1-95, pls 1-30.

———— & VOLLBRECHT, *E.*, 1931, 1932.—Die Lytophyllidae des mittleren Mitteldevon der Eifel. *Palaeontographica* **75** (3-6), 81-110, pls 15-46 (1931); **76**, (4-6), 95-120, pls 9-14 (1932).

YOH, S. S., 1937.—Die Korallenfauna des Mittledevons aus der Provinz Kwangsi Südchina. *Palaeontographica* (*A*) **87**, 45-76, pls 4-9.

ZHELTONOGOVA, V. A. & IVANIYA, V. A., 1961.—Devonskaya sistema, podklass Tetracoralla (Rugosa). *In* KHALFIN, L. L. (Ed.), 1961. 368-408, pls D27-57.

EXPLANATION OF PLATES

Unless otherwise stated, specimens are from the Emsian? Point Hibbs Limestone, Point Hibbs, west coast of Tasmania, and figures are x 2.

PLATE 1—

FIG. 1.—*Pseudamplexus princeps?* (Etheridge). 1, *a*, T.S., x 1; *b*, L.S.; UTGD 52066.

FIGS. 2-9.—*Gurievskiella abyssus* sp. nov. 2, Holotype, *a*, T.S.; *b*, L.S.; UTGD 52033/2. 3, *a*, T.S.; *b*, L.S.; UTGD 51571. 4, x 1; UTGD 89801. 5, UTGD 51989. 6, UTGD 51740. 7, *a*, T.S.; *b*, L.S.; UTGD 51739. 8, *a*, T.S.; *b*, L.S.; UTGD 52029. 9, T.S.; UTGD 89807.

FIGS 10-13.—*Martinophyllum approximans* (Chapman). 10, T.S.; UTGD 52013. 11, T.S.; UTGD 51518. 12, L.S.; UTGD 51516. 13, *a*, T.S.; *b*, L.S.; UTGD 52008.

PLATE 2—

FIGS 1, 2, 5.—*Endophyllum banksi* sp. nov. 1, Holotype, *a*, *b*, T.S., x 1; *c*, L.S., x 1; *d*, T.S., x 5; UTGD 52091. 2, *a*, T.S., x 1; *b*, L.S., x 1; UTGD 52025. 5, T.S., x 1; UTGD 52077.

FIGS 3, 4, 6-9.—*Disphyllum repansum* sp. nov. 3, *a*, T.S.; *b*, L.S.; UTGD 52205. 4, x 1; QVM 834 (1962:38:2). 6, T.S.; UTGD 52207. 7, T.S.; UTGD 52201. 8, Holotype, *a*, T.S.; *b*, L.S.; UTGD 52085. 9, T.S.; UTGD 52206.

PLATE 3—

FIGS 1, 2.—*Rhizophyllum enorme* Etheridge. 1, *a*, x 0.5; *b*, x 0.5; *c*, T.S. of juvenile stage, x 1.5; *d*, L.S. x 1.5; UTGD 51431. 2, *a*, x 0.5; *b*, T.S.; *c*, L.S.; UTGD 89799.

FIGS 3-6.—*Tryplasma* spp. 3, x 1; UTGD 51554. 4, *a*, T.S.; *b*, L.S.; UTGD 51685. 5, *a*, T.S.; *b*, L.S.; UTGD 51736. 6, *a*, T.S.; *b*, L.S.; UTGD 51664.

FIGS 7-13.—*Plasmophyllum* (*Plasmophyllum*) *tasmanicnse* sp. nov. 7, Holotype, *a*, T.S., x 1.5; *b*, T.S.; *c*, *d*, *e*, L.S., x 1.5; *f*, *g*, T.S., x 2.5; UTGD 52054. 8, *a*, *b*, T.S.; *c*, L.S.; UTGD 51656. 9, T.S.; UTGD 52033/1. 10, T.S.; UTGD 52037. 11, x 1; UTGD 52039. 12, x 1. UTGD 51528. 13, x 1; UTGD 51477.

PLATE 4—

FIG. 1.—*Gyalophyllum angelini* Wedekind. Holotype, *a*, T.S.; *b*, L.S.; *c*, L.S., x 10;*d*, T.S. x 10; T.S.-SMF 10827, L.S.—SMF 10826, Senckenberg Museum, Frankfurt, Germany. Lower Ludlovian Klinteberg Group, Klinteberg near Klintehamm, Gotland.

FIG. 2.—*Lamprophyllum degeeri* Wedekind. Holotype, *a*, T.S., SMF 11140, Senckenberg Museum; *b*, L.S., SMF 11138. Lower Ludlovian Hemse Group, Hablinglo, Petesviken, Gotland.

FIG. 3.—*Hedstrolmophyllum articulatum* Wedekind. Paratype, *a*, T.S.; *b*, L.S.; *c*, T.S. x 10; *d*, L.S. x 10; Cn 54875-6, Riksmuseet, Stockholm. Upper Llandovery, lower [Visby?] Marls, Stenkyrka, Gotland.

FIG. 4.—Gen. et sp. nov. *a*, T.S.; *b*, L.S.; UTGD 52040.

FIG. 5.—*Stortophyllum simplex* Wedekind. Holotype, *a*, L.S.; *b*, L.S., x 4; *c*, x 10; Cn 54864, Riksmuseet, Stockholm. Lower Ludlovian Eke Marls Lau-backar, Gotland.

FIGS 6, 7.—*Holmophyllum holmi* Wedekind. 6, Holotype, *a*, T.S.; *b*, T.S. x 10; Cn 54865, Riksmuseet, Stockholm. Lower Ludlovian Eke Marls, Lau-backar, Gotland. 7, Paratype, *a*, L.S.; *b*, L.S. x 10; Cn. 54866, Riksmuseet, Stockholm. Lower Ludlovian Eke Marls, Lau-backar, Gotland.

FIG. 8.—*Cystiphyllum siluriense* Lonsdale. Lectotype, L.S., Geol. Soc. Colln 6565, Geological Survey Museum, London. Wenlock Limestone, Dudley, Worcestershire, England.

PLATE 5—

FIGS 1-3.—*Favosites goldfussi* d'Orbigny. 1, *a*, T.S.; *b*, T.S., x 4; *c*, L.S.; UTGD 51764. 2, *a*, T.S.; *b*, T.S., x 4; *c*, L.S.; *d*, *e*, L.S., x 4; UTGD 51767. 3, T.S.; UTGD 52097.

FIGS 4, 5.—*Favosites carcyi* sp. nov. 4, *a*, T.S.; *b*, T.S., x 4; *c*, L.S.; UTGD 51785. 5, Holotype, *a*, T.S.; *b*, T.S., x 4; *c*, L.S.; *d*, L.S., x 4; UTGD 51781.

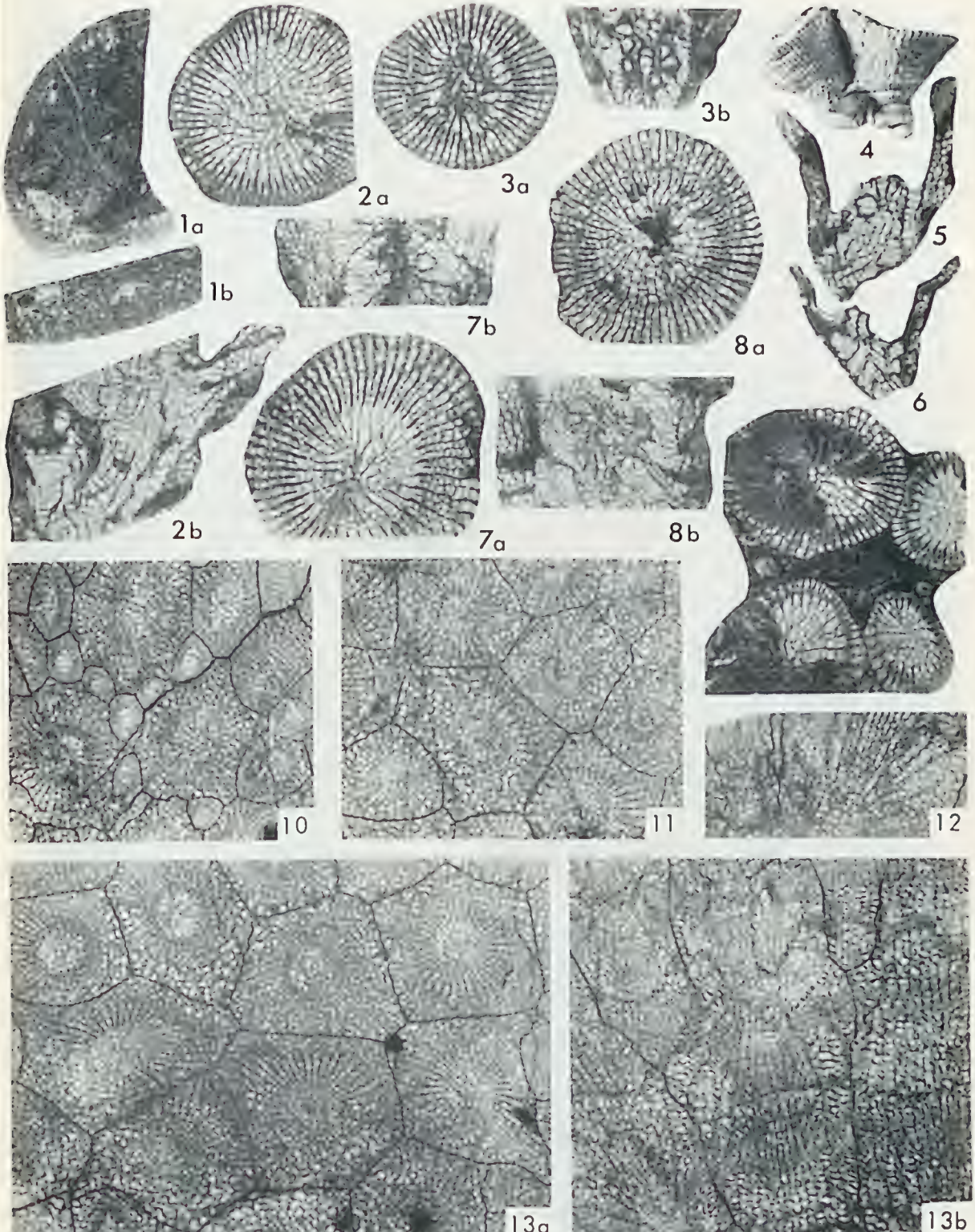
FIGS 6, 7.—*Squameofavosites bryani* (Jones). 6, *a*, T.S.; *b*, T.S., x 4; *c*, L.S.; *d*, L.S., x 4; UQGD 51778. 7, *a*, T.S.; *b*, T.S., x 4; *c*, L.S.; *d*, L.S., x 4; UTGD 52086.

PLATE 6—

FIGS 1-3.—*Cladopora* sp. 1, L.S., x 5; UTGD 89795. 2, *a*, x 1; *b*, T.S., x 5; *c*, L.S., x 5; *d*, Tg. S., x 5; UTGD 52157. 3, T.S., x 5; UTGD 89795.

FIG. 4.—*Squameofavosites bryani* var. *ramosus* var. nov. 4, *a*, x 0.5; *b*, T.S.; *c*, T.S., x 4; *d*, *f*, L.S.; *e*, *g*, L.S. x 4; UTGD 51745.

FIG. 5.—*Thecostegites ejuncidus* sp. nov. 5, Holotype, *a*, T.S.; *b*, L.S.; *c*, T.S., x 4; *d*, L.S., x 4; UTGD 51744.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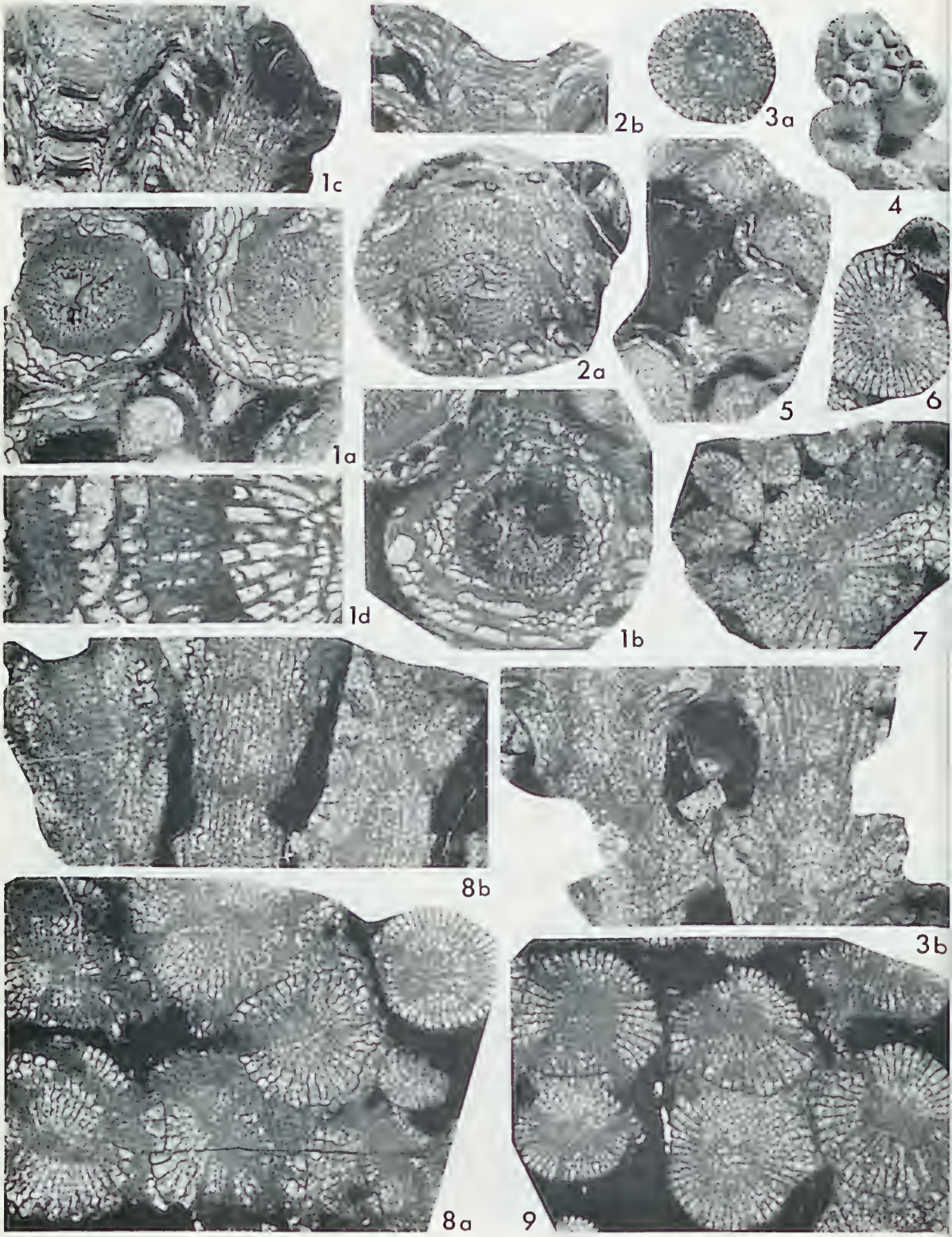

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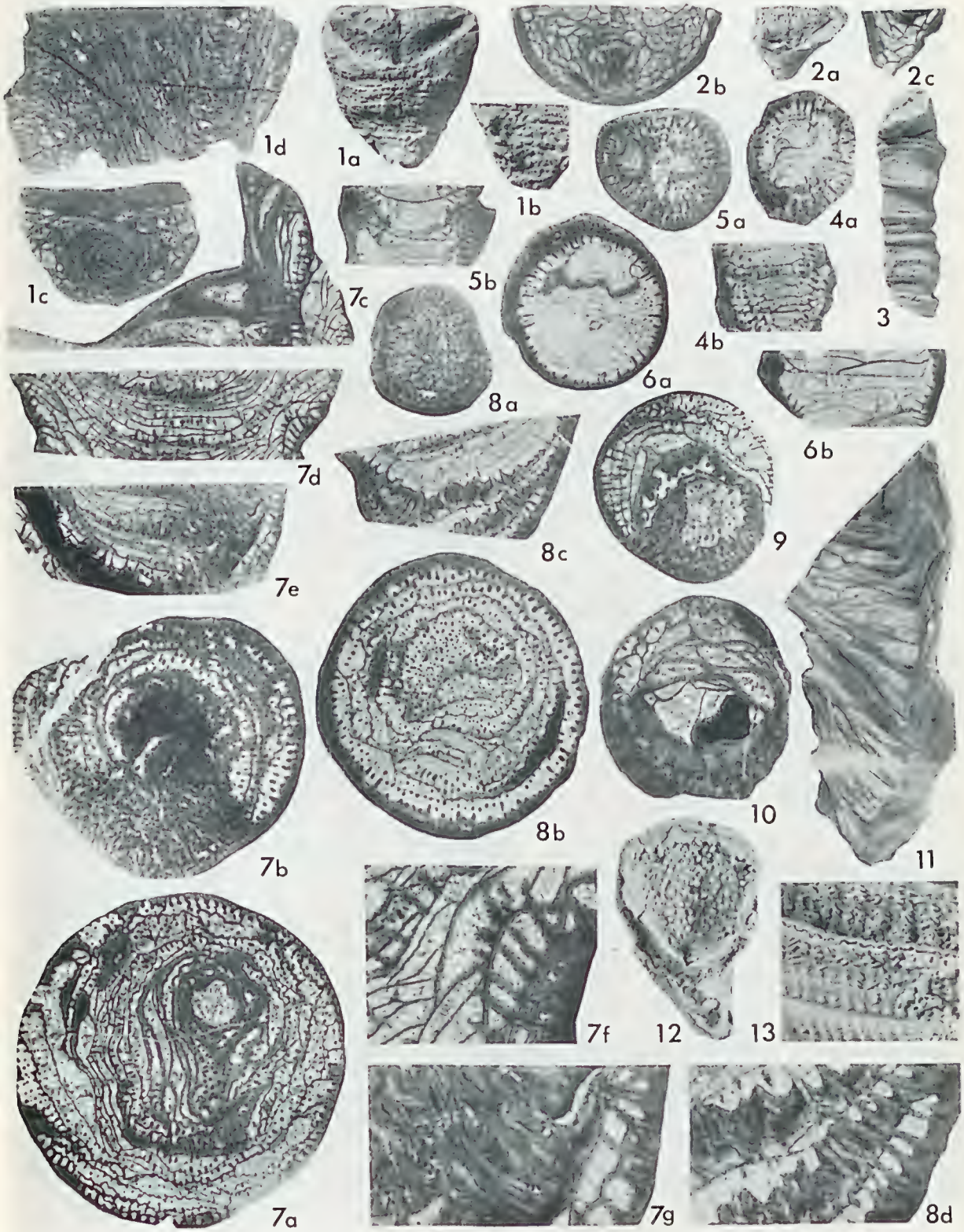
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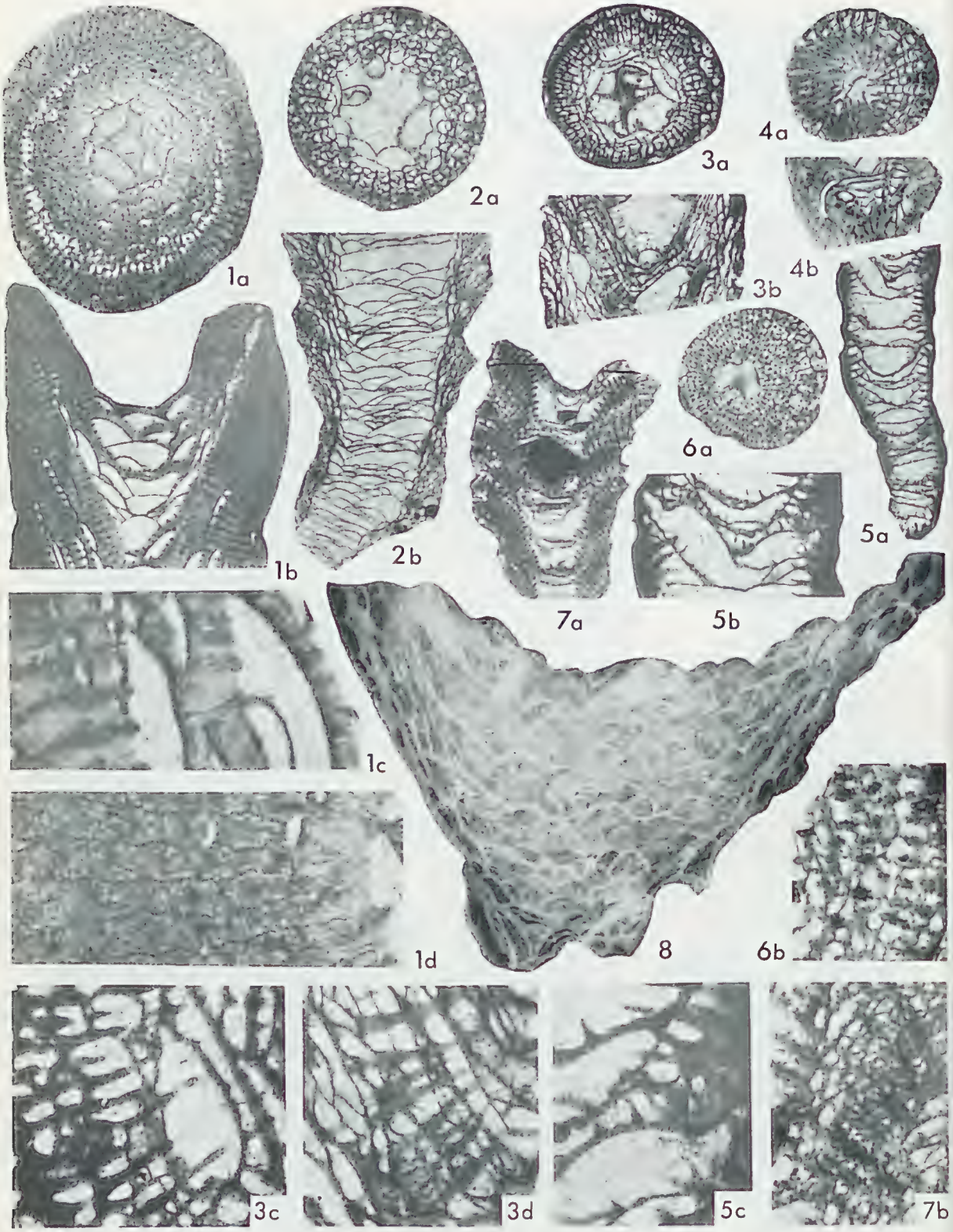

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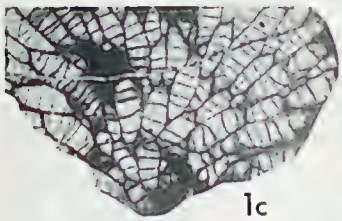
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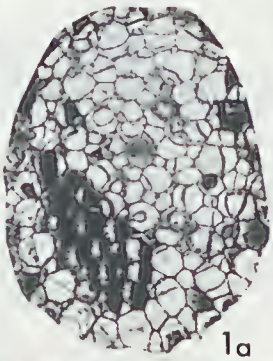
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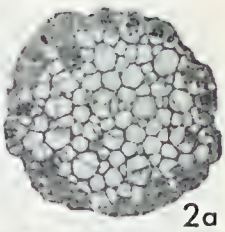
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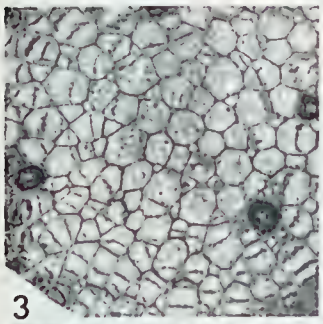
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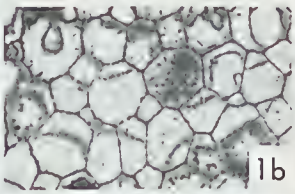
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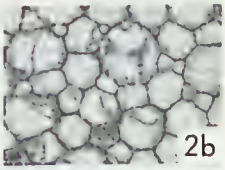
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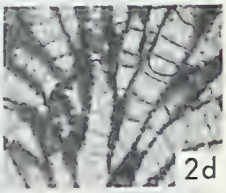
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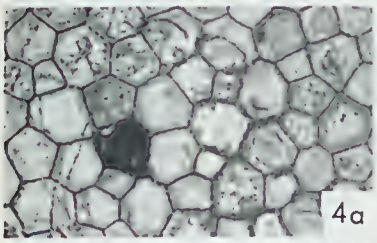
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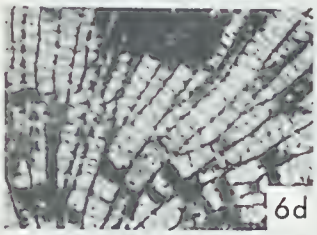
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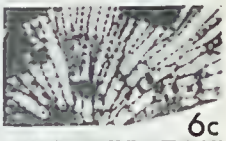
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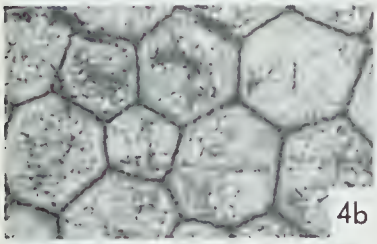
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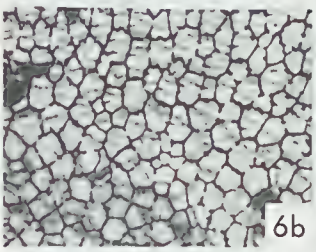
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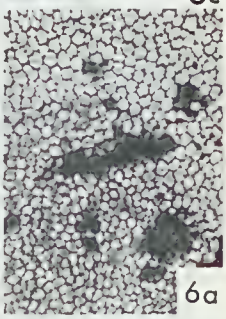
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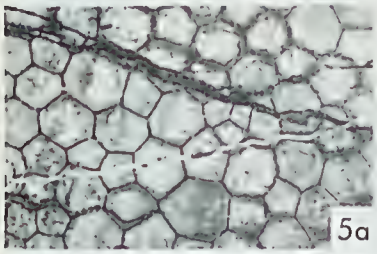
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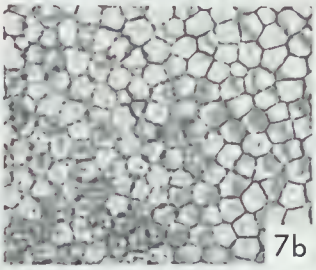
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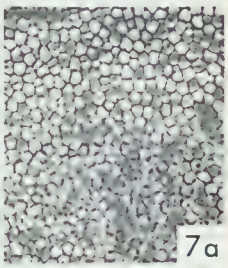
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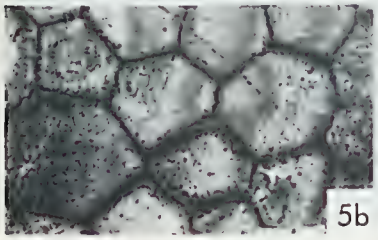
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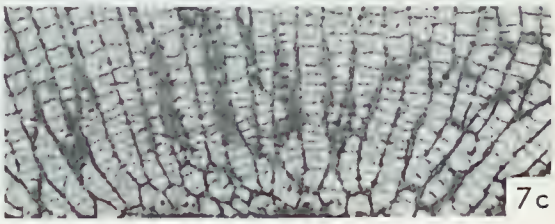
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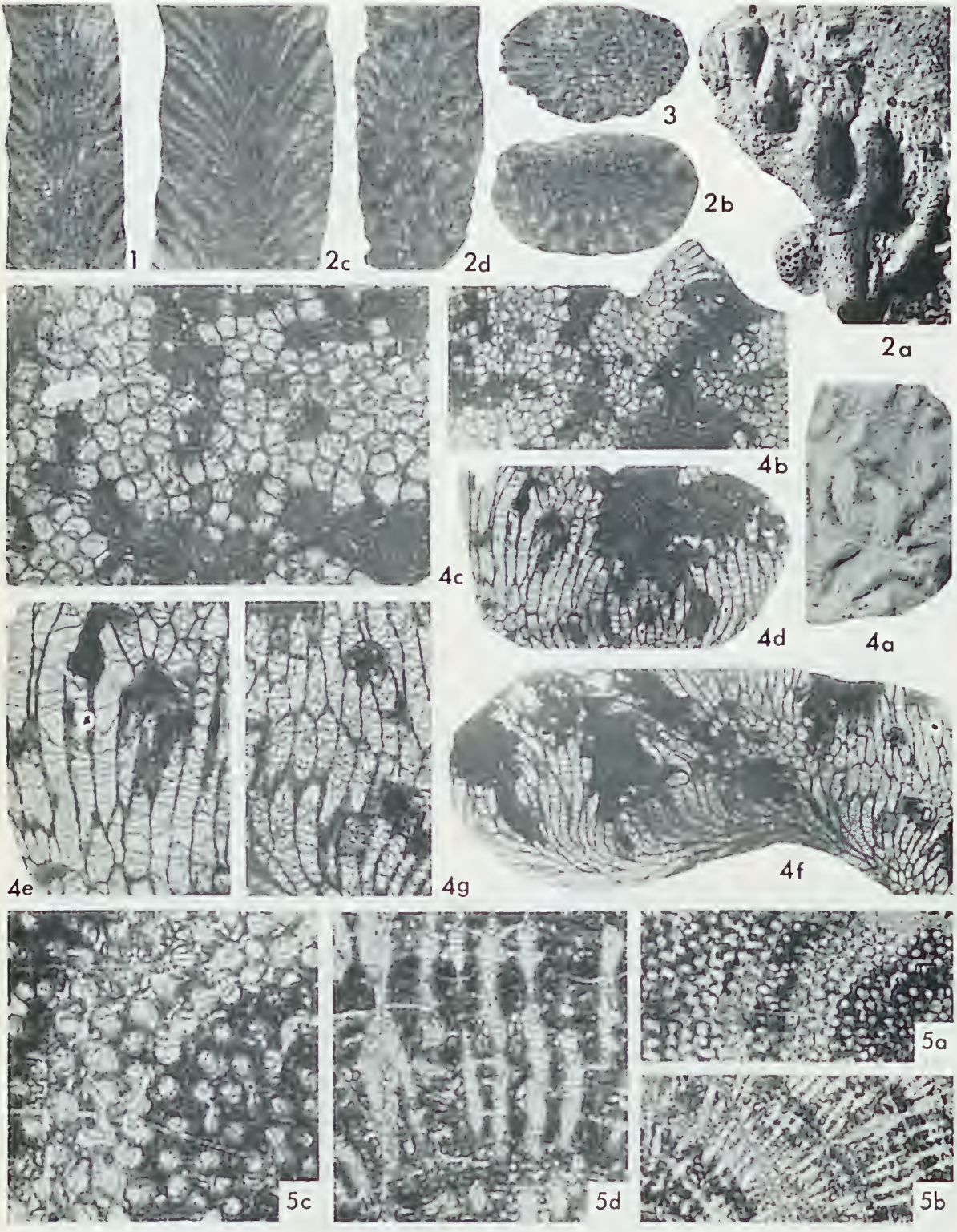

Plate 6

[*Manuscript received 30 October 1969*

CAINOZOIC VOLCANISM IN AND AROUND GREAT LAKE, CENTRAL TASMANIA

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(With five text figures and four plates)

ABSTRACT

Upper Cainozoic basaltic volcanism about Great Lake involved the eruption of a succession of mineralised entrail breccias, 215+ feet (65 m), aquagene tuffs and agglomerates, 40+ feet (12 m), unmineralised entrail breccias, 160+ feet (48 m), and massive flows and dykes, individually up to 200+ feet (60 m) thick with sequences up to four flows and 300+ feet (90m) thick. Associated with the volcanics are some lacustrine and fluviatile sediments, up to 88+ feet (27 m) thick.

The aquagene pyroclastics and entrail breccias are confined within the present Great Lake depression, and closely resemble hyaloclastites and bedded breccias in the upper parts of Icelandic intraglacial pillow lava piles. They probably represent emergent elongate fissure volcanoes that erupted into past high water levels in Great Lake.

The massive sub-aerial lavas erupted from centres both within and outlying the Great Lake depression; those within probably erupted during low or drained water levels.

Over twenty eruptive centres can be inferred on structural and petrological grounds and most are aligned along intersecting NW, NNW, N, NNE and ENE lineaments. There is some evidence of late or post-volcanic local tilting and jointing and of recent adjustment movements on lineaments.

The bulk of the volcanic rocks are tholeiitic olivine-basalt, but some tholeiite and alkali olivine-basalt occurs amongst the massive lavas. The Great Lake volcanic association is a typical example of the tholeiitic associations of Tasmania and falls within a general belt of such rocks extending from far NW Tasmania to the Derwent Valley. The Great Lake rocks resemble to some extent basalts of the Hawaiian province, and the known stratigraphy suggests a somewhat similar pattern of magmatic evolution and eruption.

INTRODUCTION

Drought conditions in Central Tasmanian catchments during 1967-68 lowered the level of Great Lake from above 3,378 feet to a low at 3,346 feet on 29 March 1968 (fig. 1), almost returning the lake to its original size and configuration prior to damming in 1923 (3,333 feet; Legge, 1904; Lewis, 1933). Large peripheral areas of the lake bottom became exposed, providing some excellent, cleanly washed outcrops of basaltic rocks. A study of these combined with detailed mapping of basalt outcrops inland, has deciphered much of the volcanic history of the region, and is reported in this paper.

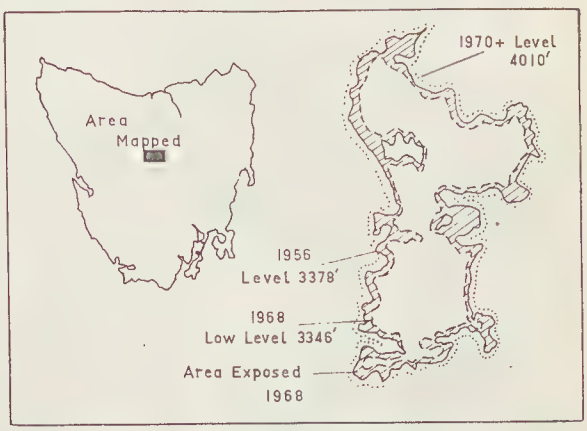

FIG. 1.—Great Lake locality and levels.

Following initial examinations of the new exposures by G. E. A. Hale in February 1968, detailed geological mapping, sampling and microscopic petrographic studies were commenced by F. L. Sutherland in March and extended inland by 1969 to cover all the basalt outcrops in the Great

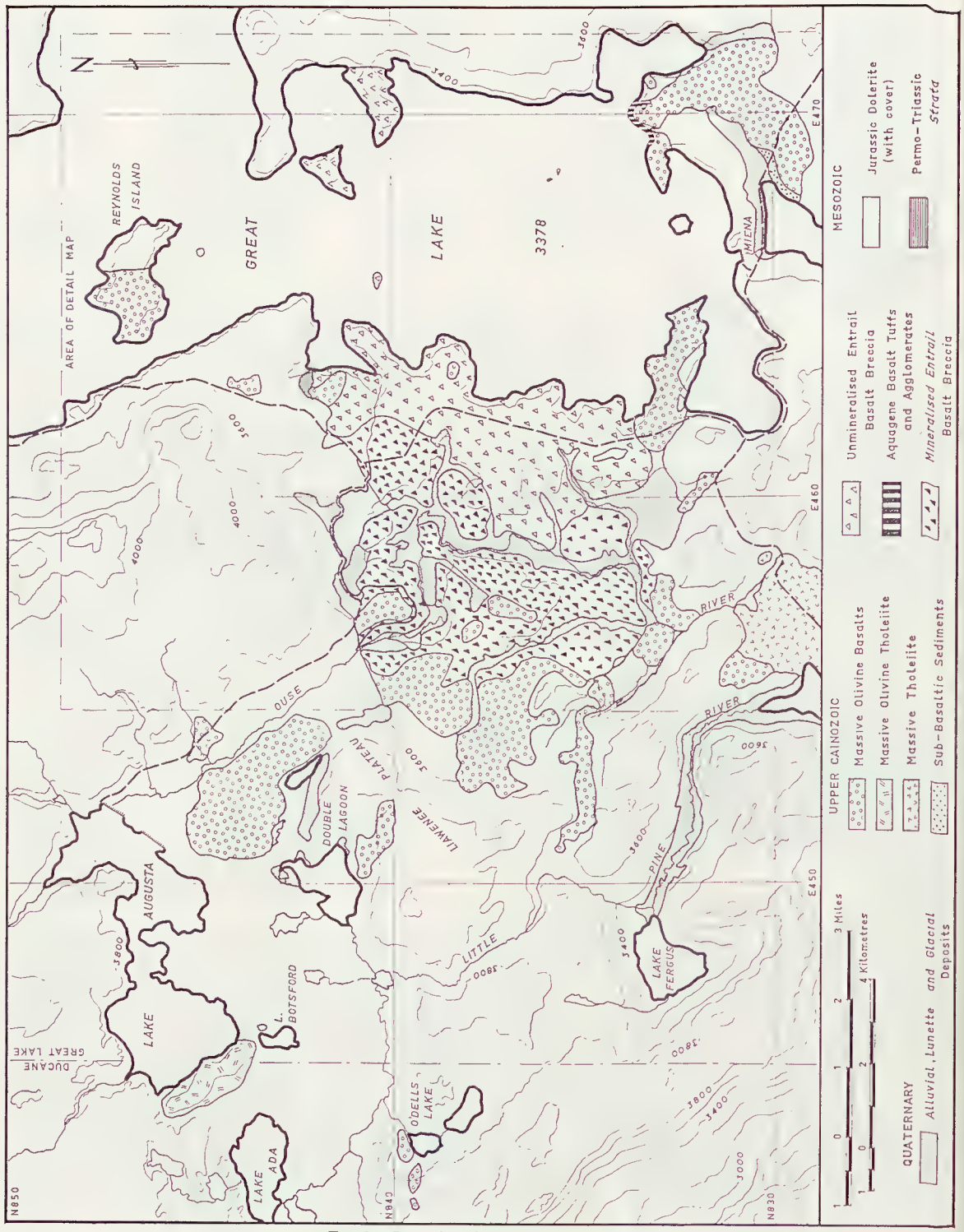

FIG. 2.—General geology, Great Lake area.

Lake Quadrangle and eastern part of the Du Cane Quadrangle (fig. 2). Samples and sections of the rocks are housed in the Tasmanian Museum collections. Chemical analyses of selected basalts were carried out by the Tasmanian Department of Mines Laboratories, Launceston.

Great Lake is refilling to 3,391 feet and with the completion of current H.E.C. works its planned level will be 3,410 feet, re-covering many of the exposures described in this paper. Photographic plates of some of the outcrops fortuitously exposed by the drought low level are included here, and an aerial photographic coverage of Great Lake flown on 3.7.1967 by the H.E.C. shows much of the bared lakesides.

PREVIOUS LITERATURE

Brief geological observations were given by Legge (1904) in his physiographical account of Great Lake and he illustrated the basaltic cliffs at the Beehives. Lewis (1933) summarised the general geology of the area, referred to geological comments of earlier workers, photographed basaltic cooling columns at 'The Battery' and suggested a glacial origin for Great Lake. Edwards (1939) discussed the physiography and age of the basalts in the area and considered the basaltic plain on the Liawenee Moor to be a 'distinctly youthful' lava surface.

In the first comprehensive regional mapping and geological account of the area, Voisey (1949) gave some details on the basalt sequences and suggested that Liawenee Moor resulted from action of an ice sheet and was not an original lava surface.

Further regional mapping and sub-surface exploration by the H.E.C. and regional mapping by the Tasmanian Mines Department produced the 1 inch to 1 mile Great Lake and Du Cane Sheets (Blake, *et al.*, 1956; Jennings, *et al.*, 1961; MacLeod, *et al.*, 1961). This provided the data for the discussions of the Jurassic dolerite and its structure, reported by Jaeger and Joplin (1955); Joplin (1957); Wiebenga and Polak (1957, 1961, 1962); Wiebenga (1958); Jaeger and Green (1958); McDougall (1958, 1964); Carey (1958); Jaeger (1964); Sutherland (1966) and most recently by Jones, Haigh and Green (1966) following a regional geophysical survey.

Amygdale minerals in the basalt breccias at Liawenee Canal were listed by Sutherland (1965). Sutherland and Corbett (1967) compared these with the amygdale minerals and basalt breccias of far NW Tasmania and suggested an aqueous origin for the Liawenee breccias.

Glacial features in the vicinity of Great Lake were mapped and discussed by Derbyshire *et al.* (1965, 1966), and Derbyshire (1968) presented evidence of older glacial deposits in the area.

STRATIGRAPHY

General

A flat basin-like intrusive sheet of Middle Jurassic dolerite underlies the Great Lake region, with minor roof remnants of Permo-Triassic strata (Jones, Haigh and Green, 1966). Further probable Permo-Triassic outcrop was mapped in this study above Canal Bay, W Great Lake, where cherty hornfels strata, at least 50 feet (15 m) thick, dip shallowly SW.

Great Lake occupies the dolerite depression, probably shaped largely by differential erosion, faulting and tilting, and glacial action to its present form.

The Cainozoic basalts and associated sediments are mostly confined to the Great Lake depression and its drainage along the Ouse and Shannon Rivers, but there are scattered basalt outcrops on the western plateau margin up to 7 miles (11 km) inland. Geophysical investigation indicated Quaternary sub-basaltic sediments at Tods Corner (Wiebenga and Polak, 1962), and H.E.C. drilling proved similar sediments in NE Great Lake. Other, scattered sedimentary deposits of probable Quaternary age within the Great Lake depression are described by Jones, Haigh and Green (1966).

The basaltic rocks include pyroclastics, entrail breccias and massive lavas, and the probable approximate succession in increasing age is:—

Massive flows and dykes 300+ feet (90 m).

Unmineralised entrail breccias 160+ feet (48 m).

Aquagene tuffs and agglomerates 40+ feet (12 m).

Mineralised entrail breccias 215+ feet (65 m).

Post-basaltic deposits include Quaternary glacial, peri-glacial and talus deposits, and fluvial and lacustrine alluvium (Legge, 1904; Lewis, 1933; Voisey, 1949; Derbyshire, 1968).

Sub-basaltic Sediments

Unconsolidated sediments underlie superficial surface deposits in a marshy depression SE of Tods Corner and occupy a trough in the dolerite bedrock, probably fault bounded to the SW (inferred from seismic profiles, Wiebenga and Polak, 1962). They lie below massive basalt S of Tods Corner, are baked near the contact and range to at least 88 feet (27 m) thick, extending from 3,367 to 3,333 feet in the NW and from 3,492 to 3,402 feet in the SW. They are considered to be mainly water-saturated clays with gravels, representing Cainozoic fluvio-lacustrine deposits. A small area of cherty hornfels near the basalt base SE of Maclanachans Point, at 3,350 feet, and baked conglomeratic beds below basalt at 3,400 feet with a marshy depression at 3,350 feet E of Shannon Lagoon, probably represent extensions of these beds.

Further sediments of similar age around Great Lake may include the siliceous conglomerate on Cramps Peninsula, considered a lithified river gravel by Jones, Haigh and Green (1966), and probable lacustrine beds intersected by H.E.C. drilling at Poatina Tunnel Inlet. The latter extend from 3,330 to 3,003 feet (41'-68' 3" depth, D.H. 5127) with a downward succession of:—

5 feet (1.5 m), black, soft to very soft clay, with a few sandy (tuffaceous?) lenses;

18 feet (5.4 m), light grey, soft, friable, laminated sandstone, with numerous plant remains and consistent 20° dip;

2 feet (0.6 m), light grey, friable, massive (tuffaceous?) sand;

FIG. 3.—Detailed geology, volcanic rocks, Great Lake area.

2 feet 3 inches, light yellow brown, very fine sandstone, with dips at 35°, and limonitic staining near base, on dolerite bedrock.

Mineralised Entrail Breccias

This series outcrops from Liawenee Canal in the north, W of Ouse River to Murderers Hill in the south (fig. 3). It is at least 215 feet (65 m) thick, marginally overlaps Jurassic dolerite and extends to unknown depth below Ouse River. Exposures are poor except in Liawenee Canal and in cliffs on Ouse River.

Successions of entrail lavas, largely brecciated, and embedded in a fragmentary rubbly and tachylitic matrix are heavily mineralised with amygdaloidal fillings and inter-fragmentary cement. Their structure is essentially similar to the unmineralised entrail breccias to the east, whose internal forms are unobscured by secondary mineralisation and are described in detail later. The secondary minerals (Sutherland, 1965) show a general paragenetic sequence, inferred from numerous partial amygdaloidal sequences, in depositional order of calcite (usually massive), phillipsite (rare), chabazite (Analysis 5, Table 1), an association of tachaaranite, tobermorite, opal and nontronite, followed by apophyllite and finally further calcite.

Dips up to 42° in the breccias suggest a series of dissected cones, mostly between 1 to 2 miles (1.5-4.5 km) across, erupted from about six centres aligned dominantly NNE which coalesced to form elongate fissure volcanoes (figs 3 and 4). They are amongst the oldest extrusions in the area, being disconformably overlain by massive lavas at Liawenee and overlapped by unmineralised breccias E of the Ouse River, but their precise age is unknown.

Aquagene Tuffs and Agglomerates

Bedded pyroclastics occur around Reynolds Island, disconformably underlying unmineralised entrail breccias and massive lavas, around Howells Island, interbedded with and disconformably underlying the breccias, and between Maclanachans Point and Tods Corner, disconformably underlying massive lava (fig. 3, plate 2). Their base is nowhere exposed. They are almost wholly basaltic, with sporadic pieces of country rocks, and show structures consistent with shallow water deposition. Vitric tuffs predominate and in thin sections show palagonitised basalt glass (Appendix 1) suggesting a sub-aqueous eruptive hyaloclastite origin, but the agglomerates may include some sub-aerial ejecta.

Reynolds Island

Outcrops from 3,385 to 3,345 feet indicate a total pyroclastic thickness greater than 40 feet (12 m). Exposures are poor in the NW, but good outcrops up to 7 feet (2 m) thick lie under basalt cappings in the SW (plate 2, fig. 1). Here, alternations of dark to light grey, finer compact and coarser friable vitric tuffs, weathering yellow, contain rarer lapilli tuffs and agglomerate in the top 3 feet (plate 2, fig. 2). Bedding is commonly irregular and wavy, and ranges from laminae about 0.5 mm thick in the fine tuffs to 30 cm thick for the agglomerate. Small-scale current ripple and tabular cross-bedding is common in some of the beds, suggesting current flow from the north.

The agglomerate contains scoriaceous basalt in angular to sub-rounded fragments, up to 5 cm and in rarer rounded bombs up to 10 cm across, embedded and grading into a lapilli tuff matrix, weathering reddish yellow. It includes sporadic angular to sub-rounded pieces of Jurassic dolerite and massive basalt, with some larger basalt bombs, up to 45 cm across; similar pieces occasionally occur in the other finer beds.

The beds are gently folded and warped, and generally strike between 15°-150° with dips mostly between 6°-15°, but locally steeper. They are cut by prominent, wide-spaced steep cross-joints, with two main sets trending at 125°-130° and 25°-30°, and small dislocations show throws of several cm (plate 2, fig. 2). The eruptive vent was apparently located off the NW end of Reynolds Island, and probably also erupted the overlying entrail breccias and massive lavas.

Howells Island

Fine and coarse vitric tuffs, at least 7 feet (2 m) thick, form small isolated pockets around Howells Island from 3,380 to 3,350 feet. They resemble the Reynolds Island occurrence, but lack the coarser lapilli tuffs and agglomerate.

They interbed with entrail breccias SW of Howells Island, and show a general strike of 115°-120° and dips up to 12° NNE. Slump and intrastratal deformational structures are common in some of the finer beds, which have a glassy baked appearance and a brittle conchoidal fracture (plate 2, fig. 3). Further north, the beds underlie the breccia, show some inverse grading and scour structures, and are more strongly warped, contorted and dislocated (plate 2, fig. 4). At one place overturned beds dip sub-vertically east, with cross-faults throwing up to 7 feet (2 m), and probably represent slide structure (plate 2, fig. 5). Such structures indicate deformation and dislocation of unconsolidated beds by emplacement of entrail breccias. The general dips suggest an eruptive source to the south, probably the same centre that erupted the entrail breccias.

Maclanachans Point

Bedded tuffs and agglomerates, weathering yellowish or reddish ochre in colour, disconformably underlie massive basalt, inland from 3,455 feet to below 3,345 feet on Great Lake shore (plate 2, fig. 6) with a maximum exposed height of almost 25 feet (8 m). The stratigraphy is complicated by folding and lateral variations, but a measured sequence from top downwards gave:—

10 (+) feet (3 m)—agglomerate

10 feet (3 m)—tuffs and agglomerate, grading from up to 3 feet agglomerate at base into lapilli tuffs interbedded with and passing into fine grained vitric tuffs at top.

3 (+) feet (1 m)—fine to medium grained vitric tuffs.

The vitric tuffs form compact, conchoidally brittle, dark grey to chocolate red, fine grained, irregular laminae, 0.5 mm to 1 cm thick, alternating with coarser, more friable beds up to 10 cm thick. They show small scale current ripple cross bedding and slump structures.

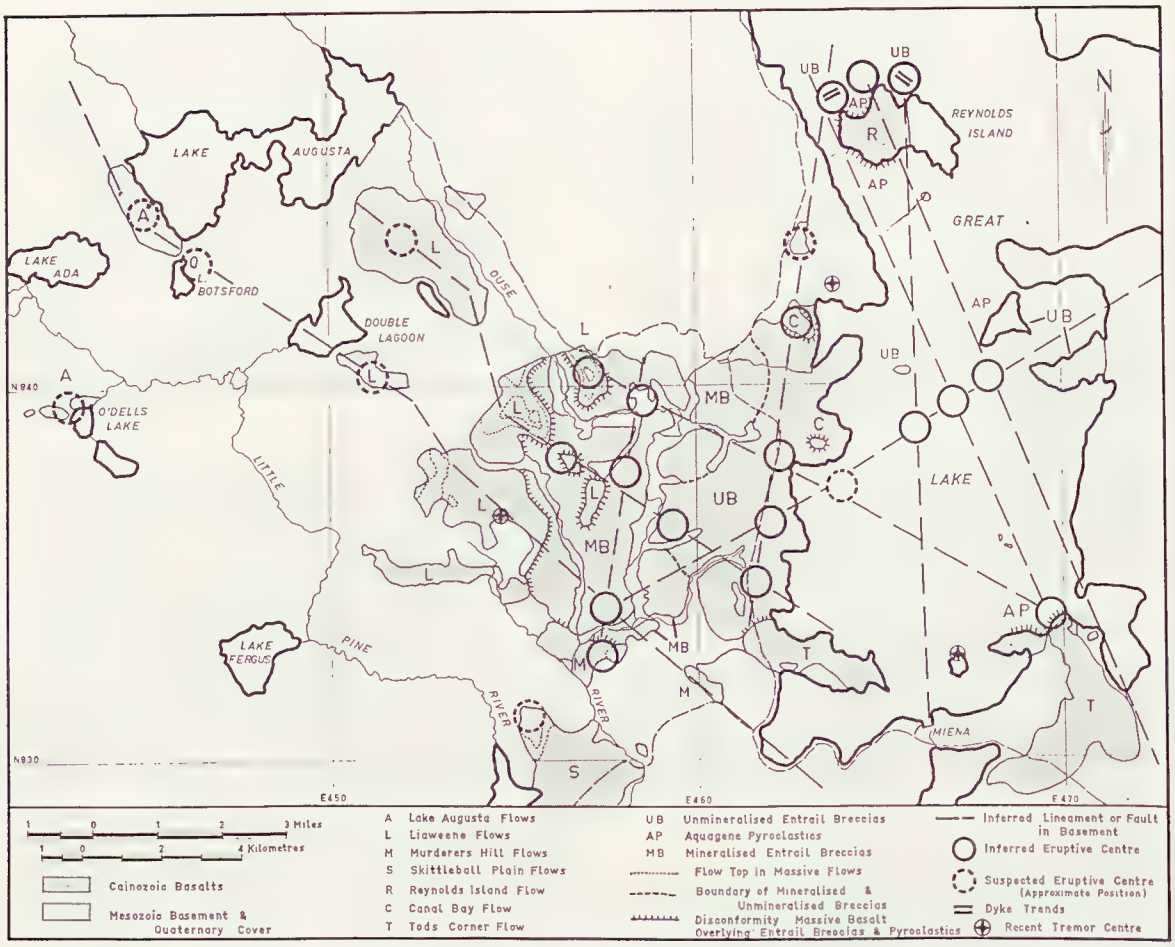

FIG. 4.—Structural geology, volcanic rocks, Great Lake area.

The lapilli tuffs contain numerous small fragments up to 0.6 mm and rare small bombs up to 4 cm across of scoriaceous basalt, in a finer vitric tuffaceous matrix. The agglomerates are similar, but scoriaceous basalt forms 20%-25% of the rock as fragments between 0.5-2.5 cm across and in larger bombs generally 5-10 cm across with hollow centres. In places basalt fragments form stringers along the bedding and there are sporadic angular fragments of Jurassic dolerite, gritty sandstone and baked cherty sediment (?), up to 10 cm across. The coarser beds show some tabular medium-scale cross-bedding.

The beds generally strike between 150°-200° and are gently folded about NNW to NNE axes; they dip at 8°-45°, but locally near-vertically. Dislocations in the beds sometimes contain reddish glassy clay, and sparse, steep blocky cross-jointing shows a dominant NNE trend. The coarse agglomerates suggest a source in the immediate vicinity.

Unmineralised Entrail Breccias

Crudely bedded entrail lavas and breccias outcrop around Reynolds Island, Howells Island and Elizabeth Bay and between Canal and Christmas Bays, W to the Ouse River (fig. 3). The series is at least 160 feet (48 m) thick, disconformably overlaps aquagene pyroclastics, mineralised entrail basalt breccias and dolerite bed rock, and disconformably underlies massive basalt flows at Reynolds Island, Canal Bay, Duck Point and Christmas Bay (fig. 3).

The beds are successions of flow units, individually up to 90 feet (30 m), but mostly between 20-60 feet (7-20 m) thick. Each unit has a base of rubbly, scoriaceous entrail basalt breccia 3-15 feet (1-5 m) thick, passing up into complete entrail lava forming the lower third to half of the unit. The upper and thicker part of the units grades into brecciated entrail lava, becoming increasingly rubbly and scoriaceous towards the top, and inter-

mingling with a finer fragmentary tachylitic matrix. Their bedding dips from near-horizontal to about 45°, but is mostly 10°-35°. Dips are difficult to measure accurately within the units and true regional dips are probably slightly less than the maximum local dips shown on the map.

As in the mineralised series, the measured dips suggest lava cones erupted from a number of centres, which coalesced in many cases into elongate fissure volcanoes. The existence of at least eight eruptive centres is inferred, aligned along intersecting lineaments, dominantly NNE and ENE in trend, with lesser NW and N trends (fig. 4). At some localities, swings of flow direction up to 90° up the succession, indicate effusion from elongate eruptive centres. Dips in the Reynolds Island exposures, although generally suggesting narrow elongate WNW to ENE trending fissure cones, show some complexities, possibly due to later dyke intrusion and massive basalt extrusion.

Sparse, steep open joints cut the breccias and are prominent SE of Canal Bay, where irregular sets trend mostly NW-WNW and NE-NEN.

The basalt in the breccias is tholeiitic olivine basalt with an abundant dark glassy matrix (Appendix 1). In the tachylitic parts the glassy base is generally palagonitised and alters to nontronitic clay. Similar basalt also forms the underlying aquagene pyroclastics and the mineralised entrail breccias.

Internal Lava Forms

The complete entrail lava consists of heaped, moulded, sinuous, sometimes anastomosing tubular basalt entrails, with dark, rough, irregular, cracked tachylitic outer crusts (plate 3, fig. 1). The entrails show slight swellings along their length and individually can be traced for tens of feet. They are circular to oval to elongately flattened in cross-section, ranging from about 9 inches (25 cm) across to 30 feet (10 m) wide in the flat, flow-like bodies. They show rough radial jointing and the tachylitic crusts are 1-8 cm thick, sometimes forming internal multiple sets.

The basalt in the entrails is dense and sprinkled with small rounded to elongate irregular vesicles. These rarely form radial or concentric trains and are mostly confined to and become increasingly abundant towards the outer margin of the entrails (plate 3, fig. 4). Central cavities in the entrails, sometimes multiple, commonly mimic in cross-section the form of the entrail, or may show flat-floored domical shapes; they form conspicuous caverns in the wider flattened bodies (plate 3, fig. 1). Vesicles and cavities are always empty. Ropy flow structure commonly forms within the larger cavities (plate 3, fig. 5), but is lacking or only incipiently developed on exterior surfaces. The basalt contains very rare inclusions of baked cherty sediment and quartz up to 10 cm across.

The brecciated lava (plate 3, fig. 2) consists of numerous, often disorientated, broken segments of entrail up to 6 feet (2 m) long. These are embedded in variable proportions of smaller, commonly angular entrail fragments, mostly 5-10 cm across, amidst a friable matrix of angular tachylitic fragments up to 2 cm across set in a clay cement. The larger entrail pieces are rare towards the tops of the flow units which are largely rubbly, with smaller, often scoriaceous fragments in abundant fine matrix. Internal, commonly multiple, tachylitic cooling crusts are common in the broken entrails, associated with cracks in the outer crust (plate 3, fig. 4). Some cracks extend into interior cavities producing chilled tachylitic and scoriaceous internal zones around cavity margins. More rarely cracks may contain tachylitic tongues of lava welled up from entrail interiors. Vesicularity also generally increases in the brecciated entrails and may produce completely scoriaceous interiors. Isolated, bulbous bodies, mostly 1 to 3 feet (0.3-1 m) across, occur sporadically through the entrail breccia, and show cracked but finely striated tachylitic crusts (plate 3, fig. 3). These may represent broken and possibly tumbled entrail toes. Many of the above features suggest brecciation more or less contemporaneous with entrail extrusion.

Age

The fresh, unaltered appearance of the rocks, with empty vesicles and cavities, suggests a comparatively young age. A small remnant of a dolerite pavement dips 4°-5° W under the breccias SE of Canal Bay at 3,345 feet, and bears striations (trend 93°-97°, plate 1) suggestive of glaciation and hence a post-Tertiary age.

The degree of subsequent erosion of the breccias and capping lavas, with evidence of glaciation of some of the later massive basalts around Great Lake, suggests that they pre-date the last late Pleistocene glaciation (about 26,500 years, Derbyshire, *et al.*, 1965). The underlying striated pavement, thus, may relate to deposits of an earlier glaciation, evident 3 miles NW and 10 miles SW, and probably significantly older than 30,400 years (Derbyshire, 1968).

Origin

The entrail bodies are identical to pillows in intraglacial Icelandic lava piles illustrated by Jones (1968, plates 1 and 4; 1969, plates 1 and 2) and considered by him to form by digital advance in the manner of slow-moving pahoehoe flow. In overall structure the entrail breccias correspond closely with the equivalent foreset bedded breccias and foreset flow foot breccias (Saemundsson, 1967; Jones, 1966, 1968; and earlier workers), considered by them to result from eruption of sub-aerial flows into water. Such an origin adequately explains sub-aqueous features in the Great Lake breccias, such as their pillow-like form and association with aquagene pyroclastics, as well as sub-aerial features they display such as strongly scoriaceous flow tops and bottoms and incipient external pahoehoe flow structures. Again, the entrails in their degree of vesicularity, general paucity in interstitial microvesicles and general absence of vesicle zoning, resemble type 2 pillows (Jones, 1969, plate 3), considered to result from partial sub-aerial degassing of lava prior to aqueous immersion. This, however, precludes the use of their vesicle size and density as an accurate indicator of water depth of emplacement.

The succession of aquagene pyroclastics, bedded breccias and massive flow cappings at Great Lake greatly resembles the upper parts of the Icelandic intraglacial volcanoes and probably those of many marine basaltic volcanoes (Jones, 1966, 1968; Saemundsson, 1967). During growth, these volcanoes erupted their products into shallow water producing phreatic bedded hyaloclastites, but on becoming partly emergent formed foreset bedded breccias, and finally the eruptions were sub-aerial yielding pahoehoe flows. The Great Lake aquagene pyroclastics and overlying entrail breccias were therefore probably erupted into a shallow water environment. The eruptions were presumably rapid, preventing accumulation of intercalated sediment as found in the pépérite lacustrine volcanoes (Jones, 1969). The capping sub-aerial flows at Great Lake, however, mainly erupted after considerable dissection of the pyroclastics and breccias and are a separate phase. The possibility that the Great Lake pyroclastics and entrail breccias represent eruption directly into glacial ice rather than a water body needs consideration, but their composite structure differs from that of described true sub-glacial eruptions (Walker and Blake, 1966; Saemundsson, 1967).

The origin of the entrail breccias is important in reconstructing the form and size of the original structures. Reconstructions based simply on bedding dips give cones built to heights mostly between 1,000 and 2,500 feet (300-800 m). This poses problems in the degree of subsequent erosion for such relatively young structures. However, if the breccias result from sub-aerial flow into water, then dips in the breccias cannot be extrapolated upwards, and the overlying lavas may have had much shallower slopes. Such table mountain structures (Jones, 1966; Saemundsson, 1967) need not exceed a few hundred feet in height.

Outcrops of the aquagene pyroclastics and entrail breccias to 3,450 feet level suggest aqueous inundation to at least this level, although folding in the pyroclastics presents some uncertainties. An aqueous stand in Great Lake near this height may correlate with the surface cut in the older mineralised breccia series and preserved under the younger massive lava cappings at about 3,500 feet. If so, then the unmineralised breccia piles probably stood little more than 250 feet (75 m) high. Change into a strongly emergent sub-aerial phase on continued eruption was probably prevented by sympathetic rises in general water level as eruptions filled the Great Lake depression.

The older mineralised entrail breccias presumably originated under similar shallow water conditions and may overlie aquagene pyroclastics. This suggests a previous stand in Great Lake with volcanoes built to heights of over 215 feet (65 m). The mineralisation presumably took place under conditions of immersion during subsequent water stand in Great Lake, accompanied by regional heating during eruption of the younger series.

Liawenee Moor, thus, was probably produced by post-volcanic erosion undermining relatively unconsolidated breccias in table mountain structures capped with solid flows. Past higher lacustrine erosion, possibly associated with seasonal surface ice action (Legge, 1904), may have been responsible as easily as action of an actual ice sheet.

Massive Flows and Dykes

Massive basalt lavas and associated dykes are widespread on the western and southern regions around and inland of Great Lake (fig. 2). Voisey (1949), Blake, *et al.* (1956) and Jones, Haigh and Green (1966) also map basalts on the S bank of Pine River Valley and on the north side of Pine Lagoon. However, detailed field and petrological microscopic examinations of these rocks suggest that they are merely locally prominent outcrops of Jurassic dolerite bedrock (Appendix 1).

The basalt flows are up to 200 feet (60 m), but mostly 20-100 feet (6-20 m) thick, either in single extrusions or successions up to four flows and 300 feet (90 m) thick. They are typically sub-aerial valley-filling and plain-flooding flows and some show strongly scoriaceous margins and/or well developed columnar cooling joints. A number disconformably overlie aquagene pyroclastics and unmineralised entrail breccias and include the youngest extrusions in the area. Generally empty vesicles, except for thin coatings of sublimate or alteration products, and flat flow tops in some lavas attest to their young age. However, some massive flows, stratigraphically isolated or overlying the older mineralised breccias, may possibly pre-date the younger unmineralised breccias and pyroclastics. The lower flow at Skittle Ball Plain has been dated Upper Cainozoic in age on palaeomagnetic evidence (Green and Irving, 1958).

In composition, the lavas range from tholeiite through tholeiitic olivine-basalt to alkali olivine-basalt. Individual flows commonly show different characteristic microscopic mineralogy and textures (Appendix 1), enabling easy delineation. The lavas erupted from at least nine separate centres and different sets of flows are described below.

Reynolds Island Flow and Dykes

This flow disconformably overlies aquagene pyroclastics and entrail breccias from 3,400 feet to below 3,350 feet, with maximum thickness of about 100 feet (30 m). It probably extends SW to Helens Island (Legge, 1904), and a poor exposure of similar basalt 1 mile NW of Canal Bay around 3,400-3,500 feet, may be a further extension, or a small separate extrusion.

The flow base shows a wavy, often irregular contact (plate 2, fig. 1). In places it develops a brecciated entrail structure, with subordinate rubbly and fine tachylitic fragmentary matrix, up to 6 feet (2 m) thick and grading into dense massive basalt. The entrail bodies are commonly cracked, with development of multiple cooling crusts, and the base is penetrated by clastic dykes and irregular inclusions of the underlying pyroclastic sediment, which may enter cracks in individual entrails (plate 2, fig. 2). This suggests basal digital advance of the lava, with localised brecciation and load casting due to flow over wet unconsolidated sediment.

A swarm of small dykes of massive basalt cuts the underlying entrail breccias NW of Reynolds Island below 3,380 feet and probably represents

the feeder system for the overlying flow (fig. 3). The dykes trend NE to ENE, range up to 20 feet (6 m), but mostly less than 5 feet (1.5 m), across, and can be traced over lengths of 130 feet (40 m). They are steeply dipping, with slightly sinuous, narrowly chilled tachylitic margins that become lobate and irregular in places. A few dykes bifurcate or send tongues up to 10 feet (3 m). long in the host rock. Dips of dyke margins suggest slight widening with depth. Jointing tends to parallel dyke margins, but there is also some cross and irregular joints, and some sidesteps in the dykes may represent small dislocations.

A few similar dykes cut entrail breccias on the NE side of Reynolds Island, but these show WNW to NW trends and may be associates of the breccias rather than the massive flow. One dyke tangentially cuts across, and shows chilled margins against, an earlier dyke.

The flow and dykes are tholeiitic olivine-basalt, with an abundant black glassy mesostasis, and contain rare inclusions of cherty and gritty sediment up to 10 cm across (Appendix 1).

Canal Bay Flow

Massive basalt with a scoriaceous margin occupies a valley at 3,450 feet W of Canal Bay, and overlies baked Permo-Triassic (?) strata to the north and unmineralised entrail breccias to the south. A small remnant of similar basalt caps the breccias above Duck Point and the flow probably originated from Canal Bay, where it attains its maximum height and thickness of about 100 feet (30 m).

The rock is tholeiitic olivine-basalt and microscopically characteristically contains glomeroporphyritic corroded augite (Appendix 1).

Liawenee Flows

Flow cappings are prominent on Liawenee Plateau, overlying dolerite at 3,850-3,700 feet, and below on Liawenee Moor, overlying mineralised entrail breccias at about 3,500 feet and infilling valleys cut in and along the dolerite scarp down to 3,350 feet at Armitage Rivulet. The flows range to 100 feet (30 m) thick and on Liawenee Moor a sequence of at least four flows reaches a maximum thickness of 250 feet (75 m) SW of Liawenee Hill. The flow SE of Lake Augusta has an extensive flat surface, but the other flows are generally more dissected.

A succession of three massive columnar and scoriaceous flows on Liawenee Hill is detailed by Voisey (1949); most of his scoriaceous zones belong to the middle flow, and the second from the top flow to the SW on Liawenee Moor has wedged out. Quarrying at the base of the top flow has exposed an intervening friable, brownish grey, fine tuff (Appendix 1). This is generally less than 1-2 feet (0.5 m) thick, but at one place extends 7 feet (2 m) upwards into a narrow irregular channel in the base of the overlying basalt, suggesting load casting. Silicified peaty material and pieces of silicified wood (mostly banksia; Dr J. Townrow, pers. comm.) were found at the base of the tuff.

The Liawenee flows are mostly alkali olivine-basalts, but some are transitional towards tholeiitic types, and the second flow in the Liawenee Hill succession is subophitic to ophitic tholeiitic olivine-basalt. Intergranular textures are typical in the large flow SE of Lake Augusta and in the lower Liawenee horizon, but glomeroporphyritic and subophitic to poikilitic textures are more common in basalt at Double Lagoon and in the upper flows on Liawenee Moor (Appendix 1).

The eruptive centres for the flows are not precisely known. The large flow on Liawenee Plateau apparently issued just SE of Lake Augusta and possibly flowed down to form the lowest flow on Liawenee Moor. The basalt at Double Lagoon apparently erupted from another local centre and may have flowed down to form the top lava on Liawenee Moor. Other possible centres may exist around Liawenee and NW of Armitage Rivulet.

Tods Corner Flow

This flow, at least 130 feet (40 m) thick, extends from Tods Corner to Shannon Lagoon, disconformably overlying aquagene pyroclastics, baked gravels and clays, and Jurassic dolerite bedrock, from 3,450 feet to below 3,340 feet on Great Lake shore (plate 2, fig. 6). The Beehives—Christmas Bay promontory is an isolated arm of the flow.

The basalt is dense with prominent cooling columns, commonly large scale but becoming small scale at The Beehives. It reaches its highest summit above 'The Battery', W of Tods Corner, where a striking change from the normal vertical and sub-vertical columns to horizontal columns (plate 10, Lewis (1933), p. 22) suggests a NW trending feeder dyke, associated with the eruptive centre for the immediately underlying pyroclastics.

The rock is tholeiitic olivine-basalt with ophitic-poikilitic texture (Appendix 1).

Skittle Ball Plain Flows

Three flows outcrop here from N of Little Pine Lagoon, W to Ouse River and S to Monpeelyata Canal. The succession from top to bottom is:—

3,500-3,450 feet—50 feet (15 m), massive columnar to scoriaceous alkali olivine-basalt,
3,450-3,4500 feet—50 feet (15 m), massive to scoriaceous tholeiitic olivine-basalt,
3,400-3,200 feet—200 feet (60 m), massive columnar to scoriaceous tholeiite.

The higher flows outcrop only N of Little Pine Lagoon, but the lower tholeiite fills an old valley of the Ouse and outcrops extensively with a strongly scoriaceous top forming much of the flat surface of Skittle Ball Plain.

The alkali olivine-basalt is intergranular type, the tholeiitic olivine-basalt is sub-ophitic to ophitic, and the tholeiite contains orthopyroxene (Appendix 1). The precise locations of the flow feeders are uncertain, but an eruptive centre may occur N of Little Pine Lagoon where the basalt reaches its highest elevation.

Murderers Hill Flows

Poorly exposed massive to scoriaceous basalt outcrops N of Murderers Hill, disconformably overlying mineralised entrail breccias and dolerite bedrock. The basalt between 3,350 and 3,250 feet fills an old valley of the Ouse and is intergranular tholeiitic olivine-basalt. This is capped by an

intergranular alkali olivine-basalt between 3,350 and 3,400 feet, extending E in an isolated arm towards Miena Hill.

These flows possibly erupted from the centre for the underlying breccias, but they also resemble the upper two flows of the Skittle Ball Plain sequence, and alternatively may have flowed upstream to Murderers Hill.

Lake Augusta Flows

Massive to scoriaceous basalts, at least 50 feet (15 m) thick, outcrop on the dolerite plateau around 3,800 feet on the W side of Lake Augusta as far as O'Dells Lake. The main outcrop at Lake Augusta is olivine-tholeiite containing orthopyroxene, and the small outcrop at Lake Botsford is alkali olivine-basalt with glomeroporphyritic augite (Appendix 1). The eastern outcrop at O'Dells Lake is tholeiitic olivine-basalt with intergranular to sub-ophitic texture and the western outcrops are alkali olivine-basalt resembling the Lake Botsford rock. These flows suggest eruptive centres on the west side of Lake Augusta and on the north side of O'Dells Lake.

STRUCTURE

The dolerite structure of the Great Lake basement is summarised by Jones, Haigh and Green (1966). Structures imposed on this basement include post-Jurassic epeiorogenic faulting, tilting and jointing, and Cainozoic volcanic edifices (already described in detail).

The major post-dolerite faulting belongs to the late Mesozoic-early Palaeocene epeiorogeny of Tasmania (Banks, 1962) and some of it may represent movements along original Jurassic structures (Sutherland, 1966). A number of structural trends can be inferred around Great Lake from field work, aerial photographic study, geophysical data and volcanic alignments.

Faults and prominent lineaments are suspected:—

1. NNW through Tods Corner, based on seismic data (Wiebenga and Polak, 1962); eruptive centres lie on this line S of Howells Island and N of Reynolds Island.
2. NNW through 'The Battery', bounding the dolerite of Becketts Bay and the straight steep margin of Great Lake N of Canal Bay; eruptive centres lie on this line at 'The Battery', E of Duck Point and NW of Reynolds Island.
3. N from Shannon Lagoon, bounding dolerite at Maclanachans Island, SE Canal Bay, Helens Island and E Reynolds Island; seamed weathered dolerite was excavated on this line at Miena Dam (Lewis, 1933, p. 24) and eruptive centres lie on it E of Duck Point and NE of Reynolds Island.
4. NW from Christmas Bay to E Lake Augusta, marked by four eruptive centres and a topographic break on Liawenee Plateau.
5. NW from Swan Bay to W Lake Augusta, marked by four eruptive centres and topographic breaks S of Miena Hill and on Liawenee Plateau.
6. NNE from Murderers Hill to Liawenee, marked by four eruptive centres.
7. NNE from Christmas Bay to Reynolds Island, marked by five to six eruptive centres.
8. ENE from Cramps Bay to Armitage Creek, marked by five eruptive centres and a strong topographic break from Sandbanks Tier.

The structural pattern (fig. 4) suggests Cainozoic volcanism located mainly along intersecting NW, NNW, N, NNE and ENE trending fissures. These trends are further reflected in fault lines mapped by Blake, *et al.* (1956) to the NE, and on the small scale by structure lines in the dolerite basement (Voisey, 1949) and dyke trends at Reynolds Island (fig. 3).

Structural trends post-dating volcanic rocks include steep sparse blocky jointing in the entrail breccias and pyroclastics, mainly as two main intersecting sets trending NWN-WNW and NEN-ENE. Dips up to 5° W on flat floors of vesicle cavities in entrail lava SE of Canal Bay, suggest slight post-eruptive westerly down-tilting, presumably from local movements on nearby NWN and N trending lineaments, possibly during later massive basalt extrusion. Tremors have been detected around Great Lake by the Tasmanian University seismic network since higher lake filling under HEC works. The tremor centres (fig. 4) lie mainly on the steep gravity gradients of Jones, Haigh and Green (1966), near suspected lineaments, and suggest minor adjustment movements on faults.

PETROLOGY AND PETROGENESIS

The Great Lake basalts range from saturated to undersaturated types (petrographic descriptions, Appendix 1; chemical analyses 1-5, Table 1; plate 4). Tholeiitic olivine-basalts, just saturated with about 50%-51.5% SiO_2 predominate and typically contain variable amounts of dark glassy mesostasis (Analyses 2 and 3). Rare, more saturated basalts contain orthopyroxene and are termed tholeiite and olivine-tholeiite (Analysis 1). Undersaturated alkali olivine-basalts form about one-quarter to one-third of the extrusions. They commonly contain titaniferous augite and are mostly near-saturated types, with some grading transitionally to the tholeiitic olivine-basalts (Analysis 4).

Although compositionally fairly uniform, the tholeiitic olivine-basalts vary considerably in texture from porphyritic hyaloophitic (Ouse and Bridgewater types) through intergranular (Jordan type), sub-ophitic (Pontville type), ophitic (Midlands type) and rarer poikilitic and glomeroporphyritic types, dependent on the cooling history (McDougall, 1959). Porphyritic hyaloophitic rocks (often palagonitised) are typical in the quenched basalt of the aquagene tuffs and entrail breccias, and also occur (non-palagonitised) in dykes and more chilled parts of massive basalts. Other textures are typical of massive basalts, with sub-ophitic to ophitic varieties typical in scoriaceous parts. Amongst the alkali olivine-basalts, porphyritic intergranular to glomeroporphyritic intergranular textures are common and some show

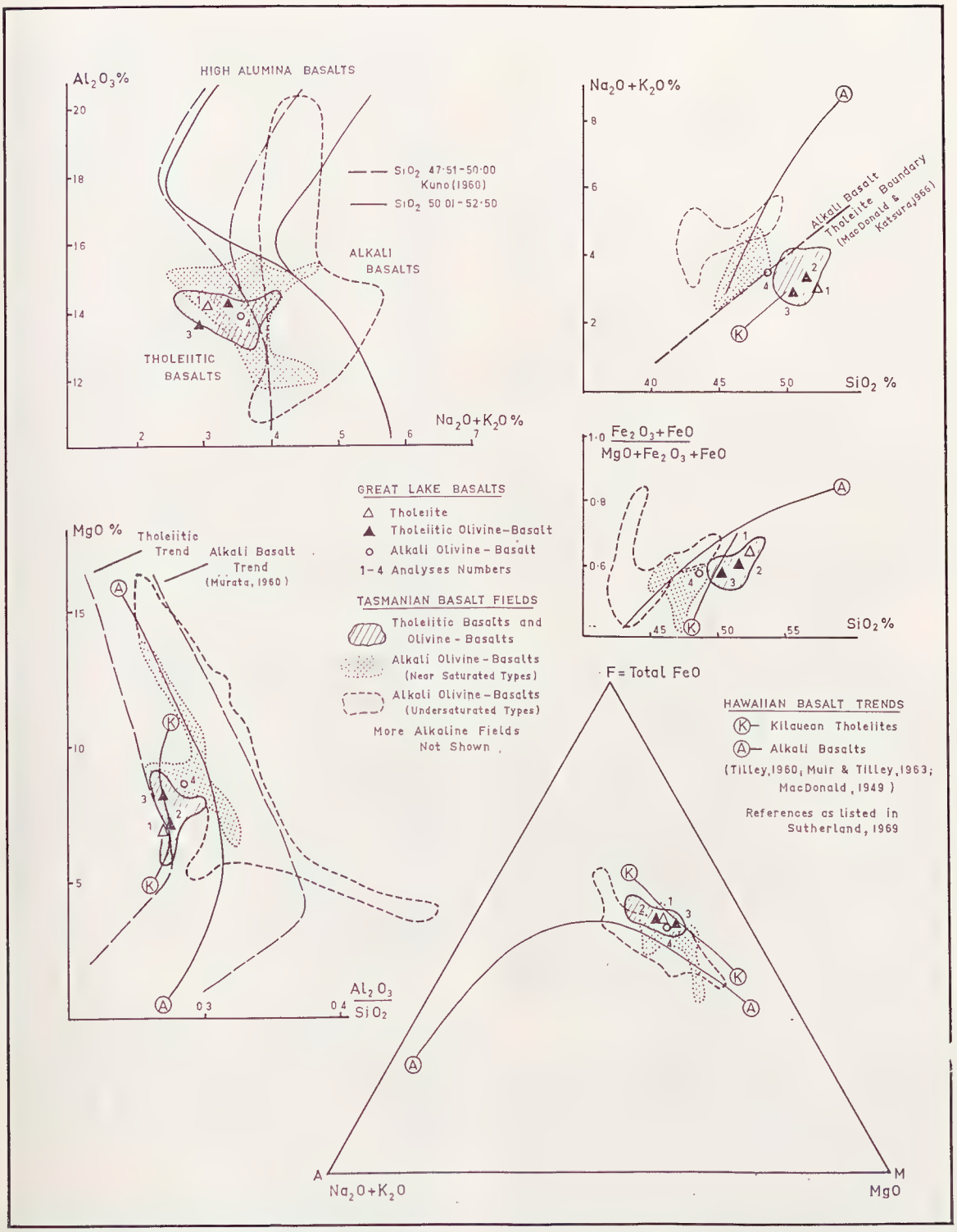

FIG. 5.—Chemical variation diagrams, Great Lake basalts, with Tasmanian basalt fields and Hawaiian basalt trends (modified from Sutherland, 1969).

sub-ophitic, ophitic or poikilitic textures, corresponding to the Mersey-Branxholm, Deloraine, and Burnie types of Edwards (1950).

The major element chemistry of the Great Lake basalts is plotted on variation diagrams (fig. 5) to show their relationships with the Tasmanian basalt fields and the Hawaiian tholeiitic and alkali basalt trends (Sutherland, 1969a). The Great Lake basalts resemble to some extent those of the Hawaiian province, interpreted as arising from segregation of parent olivine-tholeiite magma at depths of 35-70 km, with some fractionation at shallower depths to more saturated and aluminous compositions, and trends to alkaline olivine-basalt magma in waning stages of volcanism (Green and Ringwood, 1967).

The known volcanic stratigraphy at Great Lake superficially resembles a Hawaiian pattern of volcanism. The bulk of the basalts, including known older horizons, are olivine-tholeiitic types. Alkali olivine-basalts occur amongst massive flows, capping tholeiitic entrail breccias and pyroclastics, and represent later stages of extrusion. In massive flow successions that include tholeiitic lavas, the capping flow is always alkali olivine-basalt. Early minor extrusion of alkali olivine-basalt is also a possibility under initial more restricted mantle melting, prior to build up of full scale melting and tholeiitic volcanism. Most of the Great Lake alkali olivine-basalts would not fit here, but some few small stratigraphically isolated remnants on the Liawenee Plateau may do so.

SUMMARY AND DISCUSSION

Variations in form of the Great Lake lavas are attributed to extrusion under conditions ranging from sub-aqueous through partly emergent aqueous to sub-aerial, giving hyaloclastite pyroclastics, entrail breccias and pahoehoe to massive lavas respectively. The hyaloclastite pyroclastics and entrail breccias, in the absence of true pillow lavas, suggest extrusions into comparatively shallow water. Their restriction to, but widespread distribution within, the Great Lake depression implies eruption into a lacustrine environment and consequently the existence of major water stands at Great Lake at least as far back as the early stages of volcanism, probably in the Upper Tertiary. Massive sub-aerial flows overlying dissected pyroclastics and entrail breccias cut to below present lake level suggest eruptions during generally lower or completely drained water stands. Such conditions apparently existed at least during the later stages of volcanism, probably in the Pleistocene.

Lava successions, with entrail breccias resembling the Great Lake examples, occur elsewhere in Tasmania (Sutherland and Corbett, 1967; Sutherland, 1969a) and suggest extrusions into a variety of aqueous environments. Thus, the Great Lake breccias probably represent lake extrusions, possibly including intraglacial eruptions, the breccias in far NW Tasmania probably represent coastal sea extrusions, and breccias at Mersey-Forth-Sheffield probably represent extrusion into large rivers or dammed river lakes. Recent mapping by F. L. Sutherland at Bridgewater on the Derwent shore revealed a dissected bank of entrail breccias, elongate NW 1½ miles (2.4 km) and (0.8 km) wide, standing 120 feet (36 m) high and extending at least 30 feet (9 m) further below river level. This probably represents eruption into the Derwent River estuary in a past higher stand. Restricted developments of entrail lava and breccias at the base of massive flows, as at Reynolds Island in Great Lake and elsewhere in Tasmania, are thought to be lavas that flowed over small or shallow water bodies, such as small rivers and creeks, ponds, lagoons, marshes and flats of water saturated sediments.

The dissected coastal breccias in far NW Tasmania also pose difficulties in reconstruction, as do the Great Lake structures, unless a partly emergent sub-aerial structure above a confined water level is envisaged. Without this, their reconstruction requires cones 5,000-10,000 feet (1,500-3,000 m) high and corresponding water depths, for which there is no evidence on the Tasmanian coast. With this, breccia heights and water depths are at least 300 feet (90 km) but need not greatly exceed this, and Tertiary marine beds on the Tasmanian coast imply sea-levels to such heights. The NW structures were probably coastal island volcanoes, erupting lavas into the sea, but some more complete entrail lavas within them may be entirely submarine extrusions, in the lower parts or from submerged flank eruptions. The breccias at Lorinna are still largely preserved under capping massive lavas and reach about 400 feet (120 m) thick (Spry, 1958); this may indicate the approximate heights of some of the breccia structures.

The Tasmanian breccias are mineralised in far NW Tasmania (Miocene-Oligocene), in the Mersey-Forth area (probably Lower Miocene) and in the older series at Great Lake, and are unmineralised at Bridgewater and in the younger series at Great Lake (Pleistocene?). The difference is considered one of age, with the older breccias having undergone suitable mineralising conditions, such as sufficient burial by later lavas, prolonged ground or free water immersion and raised regional temperatures due to subsequent volcanism. All the mineralised breccias contain very similar suites of secondary minerals, except the NW coastal breccias in which soda-rich minerals are more prominent; this may be due to subsequent immersion or percolation by freshwater compared with seawater (Sutherland and Corbett, 1967; cf. Analysis 5, Table 1).

The Tasmanian Cainozoic entrail lavas and breccias are composed of uniform tholeiitic olivine-basalt. Poor development of such bodies amongst the equally prevalent alkali olivine-basalts of the State may be coincidental, but some factors affecting pillow formation (Solomon, 1969) were possibly optimal for the tholeiitic extrusions. Hyaloclastite pillow lavas are also known in the Tasmanian Cambrian, e.g., at King Island (Solomon, 1969), but differ in their general form from the Tasmanian Cainozoic structures, presumably due to environmental differences.

Tasmanian Cainozoic basalts tend to group geographically into distinct associations (Sutherland, 1969a). The Great Lake basalts, with those of

far NW Tasmania (Sutherland and Corbett, 1967) and Upper Mersey-Forth (Spry, 1958), can be taken as detailed examples of the tholeiitic associations, and they fall within a general belt of such rocks, extending from far NW Tasmania through Waratah, Middlesex and the Central Plateau to the Derwent Valley. These tholeiitic associations are considered to represent areas of greater mantle melting under Tasmania during Cainozoic volcanism. They contrast with the alkaline basalt associations, exemplified by the Tamar lavas (Sutherland, 1969b, 1969c), considered to represent areas of lesser mantle melting. The two associations are transitional through mixed tholeiite-alkaline basalt areas which may pass into a further mugearitic association, at present being mapped and investigated in detail.

Cainozoic tholeiite lavas, lacking olivine, such as the Skittleball Plains flow, are almost identical in mineralogy and chemistry to the Tasmanian Jurassic dolerites. Recent work indicates their presence in a number of areas (St Patricks Plains, Upper Mersey-Forth, Noland Bay, Georges Plain, Upper Macquarie River, Crown Lagoon, Woodsdale and Lune River). Thus, distinction of Jurassic or Cainozoic age is obviously unsafe on routine petrological grounds in the absence of clear field evidence or dating; this particularly applies to isolated dyke or plug bodies.

The Great Lake lavas appear to include some of the youngest in Tasmania and are comparable with the Newer Volcanics of Victoria (Upper Pliocene-Recent; Singleton and Joyce, 1969). Volcanism is now extinct at Great Lake, but measurements of present heat flow in the region, in comparison with some in the older volcanic and non-volcanic areas in Tasmania, would be of interest.

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REFERENCES

BANKS, M. R., 1962.—Cainozoic: Structure—in the Geology of Tasmania. *J. Geol. Soc. Aust.*, 9, 2, pp. 241-243.

BLAKE, F., *et al.*, 1956.—Great Lake Map Sheet. *Geol. Surv. Tasm.* 1-mile *Geol. Map. Ser.* No. 53.

CAREY, S. W., 1958.—The Isostrat, a New Technique for the Analysis of the Structure of the Tasmanian Dolerite, in *Dolerite: A Symposium.* Univ. Tasm., pp. 130-164.

DERBYSHIRE, E., 1968.—Two Geliflucfuates near Great Lake, Central Tasmania. *Aust. J. Sci.*, 31, 4, pp. 154-156.

———, *et al.*, 1965.—A Glacial Map of Tasmania. *Roy. Soc. Tasm., Spec. Publ.* 2.

———, 1966.—Discussion on the Glacial Map of Tasmania. *Aust. J. Sci.*, 29, 4, pp. 102-104.

EDWARDS, A. B., 1939.—The Age and Physiographical Relationships of some Cainozoic Basalts in Central and Eastern Tasmania. *Proc. Roy. Soc. Tasm.* for 1938, pp. 175-200.

EDWARDS, A. B., 1950.—The Petrology of the Cainozoic Basaltic Rocks of Tasmania. *Proc. Roy. Soc. Vict.*, 62, 1, pp. 97-120.

GREEN, D. H. & RINGWOOD, A. E., 1967.—The Genesis of Basaltic Magmas. *Contr. Mineral* and *Petrol.*, 15, pp. 103-190.

GREEN, R. & IRVING, E., 1958.—The Palaeomagnetism of the Cainozoic Basalts from Australia. *Proc. Roy. Soc. Vict.*, 70, 1, pp. 1-18.

JAEGER, J. C., 1964.—The Value of Measurements of Density In the Study of Dolerites. *J. Geol. Soc. Aust.*, 11, pp. 133-140.

——— & GREEN, R., 1958.—A Cross-section of a Tholeiite Sill, in *Dolerite: A Symposium*, Univ. Tasm., pp. 26-37.

——— & JOPLIN, G. A., 1955.—Rock Magnetism and Differentiation of Dolerite Sill. *J. Geol. Soc. Aust.*, 2, pp. 1-19.

JENNINGS, I. B., *et al.*, 1961.—Du Cane Map Sheet. *Geol. Surv. Tasm.* 1-mile *Geol. Map Ser.* No. 52.

JONES, B. F., HAIGH, J. & GREEN, R., 1966.—The Structure of the Tasmanian Dolerite at Great Lake. *J. Geol. Soc. Aust.*, 13, 2, pp. 527-542.

JONES, J. G., 1966.—Intraglacial Volcanoes of South-West Iceland and their Significance in the Interpretation of the Form of the Marine Basaltic Volcanoes. *Nature*, 212, 5062, pp. 586-588.

———, 1968.—Pillow Lava and Pahoehoe. *J. Geol.*, 76, 4, pp. 485-488.

———, 1969.—Pillow Lavas as Depth Indicators. *Am. J. Sci.*, 267, pp. 181-195.

———, 1969.—A Lacustrine Volcano of Central France and the Nature of Pépérites. *Proc. Geol. Ass.*, 80, 2, pp. 177-188.

———, 1969.—Intraglacial Volcanoes of the Laugarvatn Area, South-West Iceland. 1: *Geol. Soc. London Quart. Jour*, 124, 3.

JOPLIN, G. A., 1957.—The Problem of the Quartz Dolerites: Some Significant Facts Concerning Mineral Volume, Grain Size and Fabric. *Proc. Roy. Soc. Tasm.*, 93, pp. 529-549.

LEGGE, W. V., 1904.—A Physiographical Account of the Great Lake. *Proc. A.A.A.S.* Dunedin, 1904, 10, p. 348.

LEWIS, A. N., 1933.—Note on the Origin of the Great Lake and Other Lakes of the Central Plateau. *Proc. Roy. Soc. Tasm.* for 1932, pp. 15-38.

MCDOUGALL, I., 1958.—A Note on the Petrography of the Great Lake Sheet, in *Dolerite: A Symposium*, Univ. Tasm., pp. 52-60.

———, 1959.—The Brighton Basalts, Tasmania. *Proc. Roy. Soc Tasm.*, 93, pp. 17-28.

———, 1964.—Differentiation of the Great Lake Dolerite Sheet, Tasmania. *J. Geol. Soc. Aust.*, 11, 1, pp. 107-132.

MACLEOD, I. R., JACK, R. H. & THREADER, V. M., 1961.—Du Cane *Explan. Rep. Geol. Surv. Tasm.* 1-mile *Geol. Map Ser.* K'55-7-52.

SAEMUNDSSON, K., 1967.—Vulkanismus Und Tektonik Des Hengill-Gebietes In Südwest-Island. *Acta Nat. Isl.*, 2, 7, pp. 1-105.

SINGLETON, O. P. & JOYCE, E. B., 1969.—Cainozoic Volcanicity in Victoria. *Spec. Publs. Geol. Soc. Aust.*, 2, pp. 145-154.

SOLOMON, M., 1969.—The Nature and Possible Origin of the Pillow Lavas and Hyaloclastite Breccias of King Island, Australia. *Geol. Soc. London Quart. Jour.*, 124, 2, pp. 153-169.

SPRY, A. H., 1958.—Precambrian Rocks of Tasmania, Part III. Mersey-Forth Area. *Proc. Roy. Soc. Tasm.*, 92, pp. 117-137.

SUTHERLAND, F. L., 1965.—Some New Occurrences of Zeolites and Associated Minerals in the Tertiary Basalts of Tasmania. *Aust. J. Sci.*, 28, 1, p. 26.

———, 1966.—Considerations on the Emplacement of the Jurassic Dolerites of Tasmania. *Proc. Roy. Soc. Tasm.*, 100, pp. 133-146.

———, 1969a.—A Review of the Tasmainan Cainozoic Volcanic Province *Palaeovolcanology Symposium.* Canberra, 1968. *Spec Publs. Geol. Soc. Aust.*, 2, pp. 133-144.

———, 1969b.—The Mineralogy, Petrochemistry and Magmatic History of the Tamar Lavas, Northern Tasmania. *Proc. Roy. Soc. Tasm.*, 103, pp. 17-34.

——— 1969c.—The Geology and Petrology of the Tertiary Volcanic Rocks of the Tamar Trough, Northern Tasmania. *Rec. Q. Vict. Mus.* (in press).

——— & CORBETT, K. D., 1967.—The Tertiary Volcanic Rocks of Far North-Western Tasmania. *Proc. Roy. Soc. Tasm.*, 101, pp. 71-90.

VOISEY, A. H., 1949.—The Geology of the Country Around Great Lake, Tasmania. *Proc. Roy. Soc. Tasm.* for 1948, pp. 95-103.

WALKER, G. P. L. & BLAKE, D. H., 1966.—The Formation of a Palagonite Breccia Mass beneath a valley glacier in Iceland. *Geol. Soc. London Quart. Jour.*, 122, pp. 45-61.

WIEBENGA, W. A., 1958.—Exploration geophysics applied to the dolerites of Tasmania, in *Dolerite: A Symposium.* Univ. Tasm., pp. 170-183.

WIEBENGA, W. A. & POLAK, E. J., 1957.—Geophysical Survey of the Great Lake North Area, Tasmania. *Rec. Bur. Miner. Resour. Geol. Geophys. Aust.* 1957/44.

———, 1961.—Great Lake Power Development Geophysical Survey, Tasmania, 1957-59. *Rec. Bur. Miner. Resour. Geol. Geophys. Aust.* 1961/92.

———, 1962.—Arthurs Lake Diversion Aqueduct, Seismic Survey, Tasmania, 1962. *Rec. Bur. Miner. Resour. Geol. Geophys. Aust.* 1962/178.

APPENDIX 1—PETROGRAPHIC DESCRIPTIONS, GREAT LAKE BASALTS

Quoted numbers refer to thin sections catalogued in the Tasmanian Museum collection. Quoted optical properties and mineral compositions were determined as in Sutherland (1969b).

JURASSIC DOLERITE

Basalt outcrops of Voisey (1949), Blake, *et al.* (1956) and Jones, Haigh and Green (1966); S bank Little Pine River (694, 708-709, 712-718) and N bank Little Pine Lagoon (691, 711, 719, 737a).

THOLEIITE (Skittleball Plains, 695, 710, 720-724, 736, 741, 742)

Fine grained varieties contain glomeroporphyritic zoned bronzitic orthopyroxene (1%-5%, 3 mm max., $2V_x \sim 81°-69°$, $\sim$ Fs 17-23) in an intergranular to sub-ophitic groundmass of zoned labradorite laths (40%-45%, 1.2 mm max., mostly <0.3 mm, Ab $\sim$ 35-58), clinopyroxene grains (30%-40%, mostly $<$ 1 mm), blades and irregular grains of opaque titan-iron oxide (3%-6%, 0.3 mm max.), and an intersertal dark to pale brown or grey glassy mesostasis (2%-30%) charged with iron oxide globules.

These grade into fine to medium grained rocks containing glomeroporphyritic zoned orthopyroxene (5%-17%, 2.5 mm max., $2V_x \sim$ 80-59, $\sim$ Fs18-36) and zoned labradorite (up to 20%, 2.5 mm max., Ab $\sim$ 30-52) in finer grained groundmass, with brownish to pale grey mesostasis and sometimes interstitial quartz, green opal, chalcedony and clay (plate 4, fig. 4).

The orthopyroxene shows corrosion riddling, marginal alteration and replacement by zoned augite ($2V_z \sim 60°-47°$) or pigeonite ($2V_z \sim 3°-15°$, o.a.p. $\perp$ 010, but may $\parallel$ 010 marginally). The groundmass clinopyroxene is zoned augite ($2V_z \sim 60°-51°$), or pigeonite ($2V_z \sim 20°-30°$, o.a.p. $\perp$ 010, but may $\parallel$ 010 marginally) sometimes mantled with augite ($2V_z \sim 59°-45°$). Rare, corroded and altered olivine ($<$3%, 2 mm max., mostly <0.3 mm) is sometimes present. The rocks are dense to scoriaceous, commonly with empty vesicles, but sometimes with linings of chalcedony and clay.

OLIVINE-THOLEIITE (W Lake Augusta, 810, 808)

Corroded glomeroporphyritic zoned olivine (5%-8%, 2 mm max., $2V_z \sim 92°-106°$, $\sim$ Fa 19-48) and bronzitic orthopyroxene (3%-5%, $2V_x \sim 80°-70°$, $\sim$ Fs 18-26), with marginal reaction alteration to clinopyroxene (mainly augite, $2V_z \sim$ 60-54), are set in an intergranular to sub-ophitic groundmass of augite (30%-35%, 0.3 mm max., with some pigeonite) and zoned labradorite laths (40%-45%, 0.7 mm max., Ab $\sim$ 32-52), with a dark intersertal mesostasis (10%-15%) containing thin blades (3%, 0.3 mm max.) and granular globules of opaque titan-iron oxide (plate 4, fig. 3).

THOLEIITIC OLIVINE-BASALTS

Vitric Basalt Tuffs (Reynolds Island, 684, 685; Howells Island, 679-681; Maclanachans Point, 686-688).

Abundant angular to subrounded shards and fragments of pale yellow sideromelane or palagonitic glass (plate 4, fig. 1) may contain euhedral to strongly corroded fresh zoned olivine (1.2 mm max., mostly <0.7 mm; $2V_z \sim 91°-97°$, $\sim$ Fa 17-29) up to 12% in coarser bands and usually 5% in finer bands. Some olivines are broken and fragments appear in the matrix. Very rare augite and plagioclase (0.3 mm max.) and angular quartz and interlocking quartz fragments (to 1 mm) may be present.

Fragments range to 0.1 mm in the finest bedding laminae and between 0.3-3 mm across and greater in the coarser bands. Banding down to 0.5 mm thick, may be marked by incipient development of limonite and sometimes by grading with finer olivine-poor material passing into larger olivine-rich fragments. Rare, larger fragments show a halo of finely comminuted shards (plate 4, fig. 2). There are sporadic scoria fragments (to 4 mm), with smaller pieces largely altered to iron hydroxides, and rare pieces of hyaloophitic basalt. The base (10%-35%) is an opaline and chalcedonic cement with irregular pore spaces.

Entrail Basalt Breccias (Mineralised Series, Liawenee Canal, 482; Unmineralised Series, Ouse River, 677, Reynolds Island, 678, SE Canal Bay, 683).

The unaltered basalt consists of porphyritic to glomeroporphyritic corroded zoned olivine (5%-15%, 1.8 mm max., $2V_z \sim 89°97°$, $\sim$ Fa 13-29) and zoned partly skeletal plagioclase laths and crystallites (25%-55%, 0.8 mm max., Ab $\sim$ 40-52) in a black opaque to dark brown hyaloophitic glassy base containing clinopyroxene and small patches of opal and chalcedony. Rare plagioclase, with resorbed cores may be present.

The altered basalt of the tachylitic entrail crusts and fragmentary matrix is pale greenish yellow sideromelane or palagonite showing perlitic cracks and sparse vesicles, and containing scattered glomeroporphyritic olivine (12%), plagioclase laths (5%), and numerous crystallites. Matrix fragments are angular to subrounded, commonly 0.2-10 mm across, in a dark opaque to brownish limonitic and clayey cement. In the mineralised series this

cement is replaced with suites of secondary minerals (see text).

Porphyritic Hyaloophitic Basalts (Reynolds Island, 673, 673a, 682; N Canal Bay, 674; W Murderers Hill, 730, 731).

These contain corroded to euhedral glomerophenocrysts, phenocrysts and grains of zoned olivine (8%-15%, 1.8 mm max., $2V_z \sim 88°$-$98°$, $\sim$ Fa 11-31), laths of zoned labradorite (30%-45%, 1 mm max., Ab $\sim$ 38-52), grains and crystallites of augite (15%-25%, 0.3 mm max.), and a dark glassy hyaloophitic to intersertal mesostasis with patches of opal, chalcedony, clay and minor carbonate. The Reynolds Island rocks may contain feldspathic quartz sandstone and quartzitic inclusions, showing some fused grain boundaries.

Porphyritic Intergranular Basalts (Canal Bay, 675; Duck Point, 676, 759).

Corroded zoned olivine (5%-12%, 1.5 mm max., $2V_z \sim 92°$-$107°$, $\sim$ Fa 19-50) is interspersed in an intergranular to sub-ophitic groundmass of zoned labradorite laths (35%-45%, 2.4 mm max., Ab $\sim$ 37-58) and zoned augite (25%-35%, 1.2 mm max., $2V_z \sim 63°$-$49°$), with an intersertal brown glassy mesostasis (15%-25%). Augite, and occasional labradorite, shows corrosion riddling, and glomeroporphyritic augite sheaves and aggregates may form to 3 mm across.

The mesostasis associates with thin elongate ilmenite blades (3%-4%, 1.2 mm max.) and contains acicular crystallite sheaves, apatite needles, grains and globules of opaque titan-iron oxide and patches of chalcedony and clay. The rock grades marginally into sub-ophitic basalt.

Porphyritic Sub-ophitic Basalt (Skittleball Plains, 738-740; Liawenee Moor, 754, 754a, 1150, 1154, 1155, 1161, 1162; N O'Dells Lake, 799, 807).

Corroded zoned olivine phenocrysts and grains (2%-17%, 3.6 mm max., $2V_z \sim 88°$-$101°$, $\sim$ Fa 11-37), sometimes show marginal reaction alteration to granular augite, and are scattered in an intergranular to sub-ophitic-ophitic groundmass of zoned labradorite laths (35%-45%, 1 mm max., Ab $\sim$ 37-58), zoned augite (35%-40%, 1 mm max., $2V_z \sim 62°$-$42°$), titan iron oxide blades and grains (3%-6%, 0.8 mm max.) and brown to grey glassy mesostasis (2%-15%) with interstitial greenish opal (up to 15%).

Porphyritic Ophitic Basalts (Beehives, 692, 693; Tods Corner, 689, 728; Shannon Lagoon, 733, 734).

Corroded zoned olivine phenocrysts and grains (8%-12%, 1.8 mm max., $2V_z \sim 91°$-$100°$, $\sim$ Fa 17-35) and zoned labradorite laths (35%-40%, 0.6 mm max., Ab $\sim$ 37-52) are intergrown with ophitic to poikilitic zoned augite (30%-45%, 3 mm max., $2V_z \sim 62°$-$51°$). The mesostasis passes from abundant hyaloophitic opaque black glass (25%) containing augite (plate 4, fig. 5), to ophitic augite ($2V_z \sim 61°$-$44°$), blades and grains of titan-iron oxides (3%-6%, 0.6 mm max.), intersertal greyish brown glass (5%), and patches of opal, chalcedony and clay.

Rare inclusions of fused quartzitic sandstone show corroded quartz grains in a clear to brown glassy base with flow lines. Streamed drops and patches of devitrified greenish opaline glass, numerous small cordierite crystals with opaque iron oxide concentrated in the cores, sporadic sheaves of sillimanite with granular haloes of opaque iron oxide, rare sanidine, and tridymite (?) occur in the glassy base.

Alkali Olivine-Basalts

Porphyritic Intergranular Basalts (Liawenee Moor, lower levels below 3,500 feet, 725, 727, 748, 1151, 1156, 1158-1160; Liawenee Moor, upper levels above 3,500 feet, 726, 1153, 1157, 1163, 1164; Liawenee Plateau, S Lake Augusta, 749, 750, 752, 752a, 753, 753a; S O'Dells Lake, 797; Lake Botsford, 798; Murderers Hill, 696, 732; Skittleball Plains, 690, 735).

Euhedral to strongly corroded zoned olivine phenocrysts, grains and rare granular aggregates (10%-25%, 2.4 mm max., $2V_z \sim 86°$-$100°$, $\sim$ Fa 7-36), sometimes show part alteration to serpentine, translation lamellae or strain polarisation. The groundmass is intergranular, with zoned, sometimes fluidal, labradorite laths (30%-45%, 0.8 mm max., mostly <0.3 mm, Ab $\sim$ 34-62), colourless to pinkish titaniferous augite (20%-35%, 0.8 mm max., mostly <0.3 mm), blades and grains of opaque titan-iron oxide (3%-5%, 0.6 mm max.), and interstitial material including zeolites (up to 15%, mainly chabazite, rarely with natrolite), green to yellow serpentinitic clay, chalcedony, opal and rarely carbonate. Amygdales may contain zeolites, clays or carbonates.

Some rocks show scattered to glomeroporphyritic microphenocrysts and phenocrysts of zoned titaniferous augite, best developed in the Lake Botsford rock (up to 5%, 1.5 mm max., colourless to faintly pleochroic from pale fawn to pinkish mauve, with normal, hourglass and oscillatory zoning, $2V_z \sim 64°$-$40°$). Rare plagioclase phenocrysts (1.2 mm max.) show corrosion riddled cores and narrow overgrowths. Fused sediment replaced by clinopyroxene, quartzitic fragments and rare small peridotite inclusions may be present.

Porphyritic Sub-ophitic Basalt (Liawenee Plateau, Double Lagoon, 750a, 751).

Corroded zoned olivine phenocrysts and grains (20%-25%, 2.4 mm max., $2V_z \sim 88°$-$100°$, $\sim$ Fa 11-36) occur in a groundmass of zoned labradorite laths (30%-40%, 0.6 mm max., Ab $\sim$ 36-56), intergranular to sub-ophitic elongate prisms and grains of zoned titaniferous augite (20%-25%, 0.6 mm max., X faint mauve, Y mauve, Z pale fawny mauve, $Y > Z \simeq X$, $2V_z \sim 72°$-$51°$), and intersertal dark glassy mesostasis (15%-20%).

Porphyritic Ophitic Basalt (Liawenee Moor, top flow, 747, 747a, 1152).

Corroded zoned olivine phenocrysts (5%-12%, 2 mm max., $2V_z \sim 88°$-$98°$, $\sim$ Fa 11-31) and rare plagioclase phenocrysts (2.4 mm max., with corrosion riddled cores infilled with clinopyroxene and iron ore) are set in ophitic to poikilitic groundmass of small zoned labradorite laths (35%-45%, 0.6 mm max., mostly <0.3 mm, Ab $\sim$ 36-58) enclosed in large plates of faintly pleochroic zoned titaniferous augite (25%-35%, 1.5 mm max., $2V_z \sim 67°$-$42°$), with interspersed blades and grains of opaque

titan-iron oxide (4%-6%, 0.6 mm max.) and interstitial serpentinitic clay (up to 15%).

The rock (plate 4, fig. 6) appears to represent a more completely crystallised variety of the Double Lagoon rock, and is transitional and closely similar to the tholeiitic ophitic olivine-basalt of the Tods Corner flow.

Vitric Tuff (Liawenee Hill, below top flow, 1146).

This contains small angular to subrounded fragments (<0.2 mm) of basalt glass (95%), rare titaniferous augite and very rare olivine. It probably represents a fine explosive phase of the overlying porphyritic ophitic basalt.

TABLE 1—CHEMICAL ANALYSES AND C.I.P.W. NORMS, GREAT LAKE BASALTS

Analysis	1	2	3	4	5
SiO_2	52.3	51.5	50.1	48.6	47.3
Al_2O_3	14.2	14.2	13.6	13.9	18.2
Fe_2O_3	1.4	1.1	2.5	2.4	—
FeO	9.5	10.2	9.1	9.9	—
MnO	0.16	0.17	0.17	0.17	—
TiO_2	1.7	1.6	1.8	1.8	—
P_2O_5	0.23	0.24	0.27	0.29	—
CaO	9.3	8.5	8.6	8.2	9.0
MgO	6.9	7.1	8.3	8.6	—
Na_2O	2.5	2.5	2.4	2.7	0.38
K_2O	0.56	0.87	0.52	0.84	1.6
H_2O-	0.83	0.42	1.2	1.2	—
H_2O+	0.30	0.69	1.0	0.71	23.8
CO_2	0.20	0.92	0.20	0.26	—
Total	100.08	100.01	99.76	99.57	100.28

C.I.P.W. Norm	1	2	3	4	5
Q	4.10	3.09	2.40	—	—
Or	3.31	5.14	3.07	4.96	—
Ab	21.16	21.16	20.31	22.85	—
An	25.87	24.96	24.80	23.33	—
Di	*14.37*	*8.10*	*12.06*	*11.26*	—
En	3.92	2.13	3.71	3.36	—
Fs	3.14	1.87	2.16	2.13	—
Wt	7.31	4.10	6.19	5.77	—
Hy	*23.85*	*29.13*	*26.74*	*20.71*	—
En	13.26	15.55	16.95	12.70	—
Fs	10.59	13.58	9.79	8.01	—
Ol	—	—	—	*6.35*	—
Fo	—	—	—	3.74	—
Fa	—	—	—	2.61	—
Mt	2.03	1.60	3.63	3.48	—
Il	3.23	3.04	3.42	3.42	—
Ap	0.55	0.57	0.64	0.69	—
Ca	0.46	2.09	0.46	0.59	—
$H_2O\pm$	1.13	1.11	2.20	1.91	—
Total	100.06	99.99	99.74	99.55	—

1. Tholeiite. Massive flow, S bank Ouse River, Marlborough Highway, Skittleball Plains, .
2. Tholeiitic olivine-basalt. Massive flow, Shannon Lagoon, quarry E side Lake Highway. .
3. Tholeiitic olivine-basalt. Entrail breccias, SE of Canal Bay, Great Lake .
4. Alkali olivine-basalt (transitional type). Massive flow, quarry in top flow, Liawenee Hill, Great Lake.
5. Chabazite. Mineralised entrail breccias, Liawenee Canal, Great Lake. .

Analyses by Tasmanian Department of Mines Chemical Laboratory, J. Furst, Analyst.

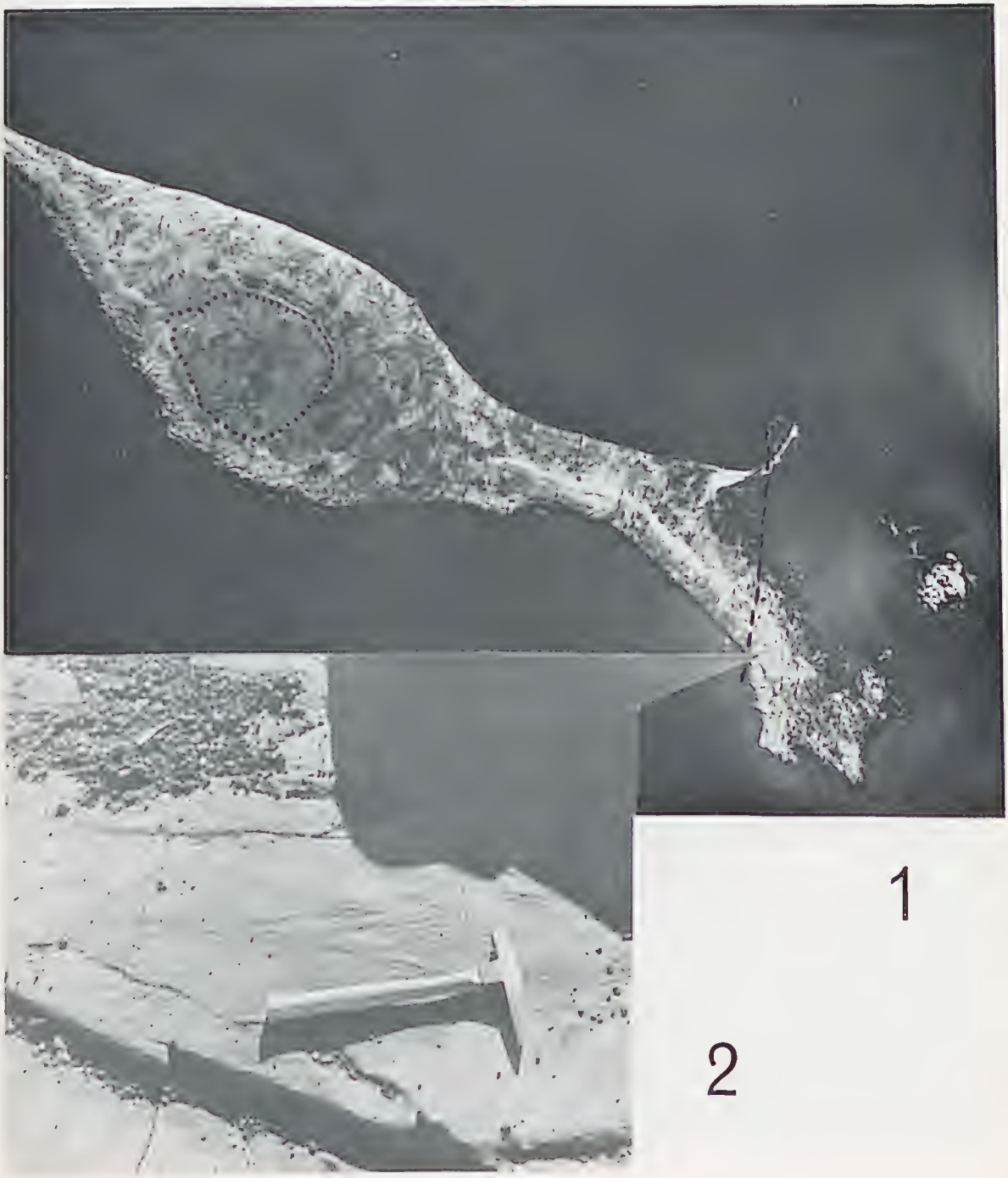
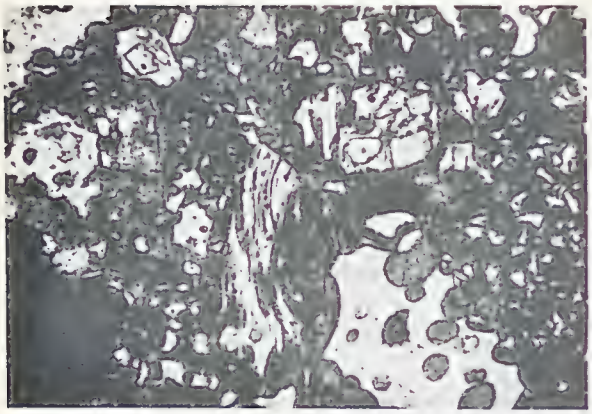


PLATE 1—

Fig. 1.—Peninsula SE of Canal Bay, uncovered by lowered level in Great Lake (Little Neck of Legge, 1904). H.E.C. aerial photograph. Great Lake, Run 4, 71842, 3 July 1967. Previously submerged land is indicated outside dotted line. Cliffs of basalt breccias are exposed on SW side and the underlying dolerite basement is exposed on E side, marked off by dashed line.

Fig. 2.—Pre-basaltic striated dolerite pavement remnant, at basalt-dolerite contact on peninsula, SE of Canal Bay, looking N. Its position on the aerial photograph (fig. 1) is indicated by arrow tab.



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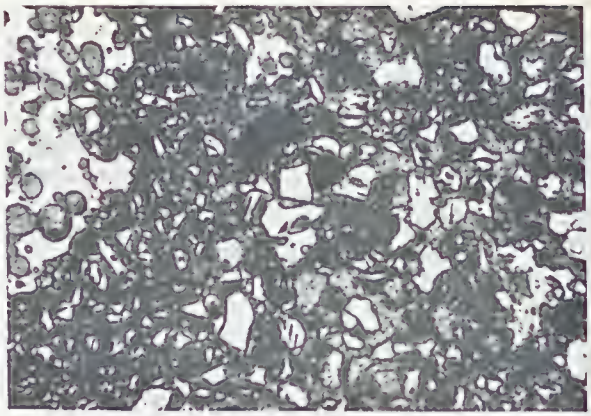

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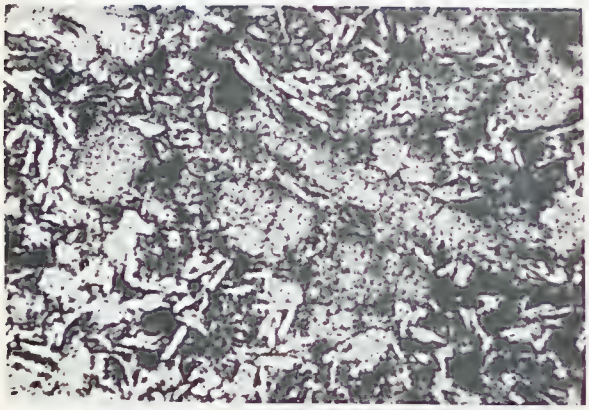

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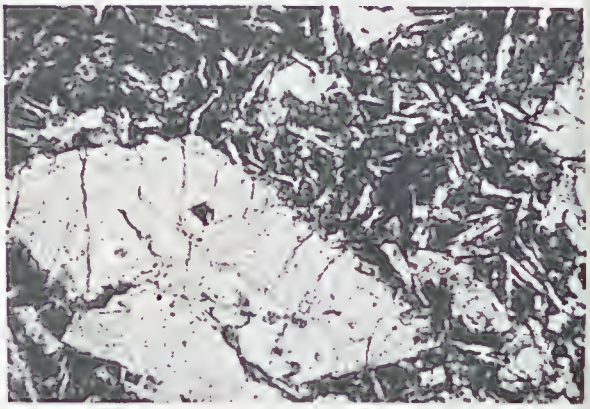

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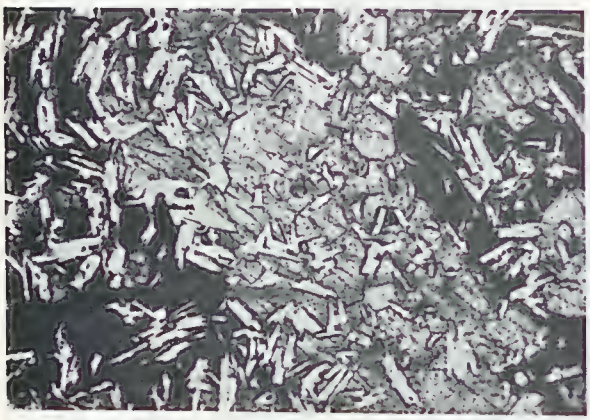

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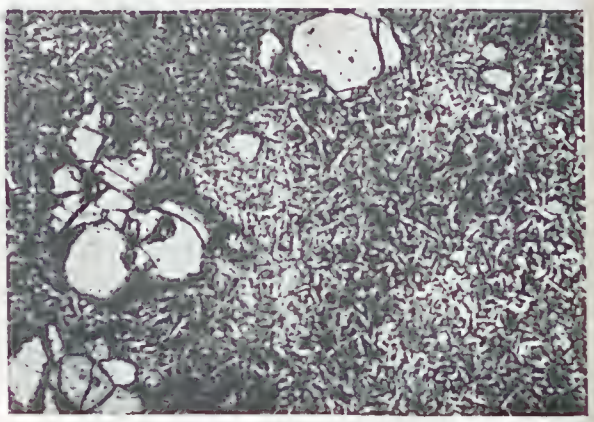

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1MM.

PLATE 4—

FIG. 1.—Coarse aquagene tuff, showing fragments of palagonitised basalt glass, containing small olivine crystals, and sometimes showing vesicle flow structure (centre). E of Maclanachans Point. T.S. 688. Microslide photograph—uncrossed nicols.

FIG. 2.—Coarse aquagene tuff. Note halo of small comminuted shards around large fragment on left. Locality as above. T.S. 688. *Ibid.*

FIG. 3.—Olivine-tholeiite, showing phenocrysts of bronzitic orthopyroxene. W Lake Augusta. T.S. 808. *Ibid.*

FIG. 4.—Tholeiite, showing porphyritic texture with zoned labradorite (left) and bronzitic orthopyroxene (far right). Skittleball Plains. T.S. 736. *Ibid.*

FIG. 5.—Tholeiitic olivine-basalt, Tods Corner flow, showing poikilitic augite (centre) with zoned labradorite laths, olivine and black glassy mesostasis. The Beehives, T.S. 692. *Ibid.*

FIG. 6.—Alkali olivine-basalt, top Liawenee flow, showing poikilitic titan-augite (light areas), with feldspar laths, olivine phenocrysts and serpentinitic mesostasis (dark areas). Quarry, top of Liawenee Hill. T.S. 747a. *Ibid.*

[*Manuscript received 10 November 1969*

OBSERVATIONS ON SOME TASMANIAN FISHES: PART XVII

By

E. O. G. SCOTT

(One text figure)

ABSTRACT

Three species are added to the Tasmanian list: *Ichthyocampus cristatus* McCulloch & Waite, 1918 (Syngnathidae), *Scorpis lineolatus* Kner, 1865 (Scorpidae), *Pseudolabrus parilis* (Richardson), 1850 (Labridae): some general observations are made on these species. *Coelorhynchus mortoni* Ogilby, 1897 (Macruridae), relegated in the Check-List to the synonymy of *C. australis* (Richardson), 1849, is reinstated as a valid species, and a redescription and figure, based on material from the West Coast, are supplied. Other species discussed are *Raja whitleyi* Iredale, 1938 (Rajidae) [metrical data on 17 examples], *Vincentia lemprièri* (Johnston), 1883 (Apogonidae) [new material], *Neoplatycephalus speculator* (Klunzinger), 1872 (Platycephalidae) [confirmation of Tasmanian status], *Platycephalus bassensis bassensis* Cuvier, 1829 (Platycephalidae) [variation in fin counts]. Tasmanian representatives of the families Scorpidae, Platycephalidae, and Australia and New Zealand species of the genus *Coelorhynchus* Giorna, 1809 are keyed.

INTRODUCTION

This paper follows the general plan of the others in the series. Where the unit of length measurement is not given, millimetre(s) is to be understood. The abbreviations *Ls, Lt, TLs, TLt* denote standard length, total length, thousandths of standard length, thousandths of total length, respectively. Certain other conventions are noted in earlier contributions. Parts I-XV are published in this journal, 1934-1967; Part XVI appears in *The Australian Zoologist*, 15, 2, 1969: 160-177, figs 1-2.

Family RAJIDAE

Genus **RAJA** Linné, 1758

Raja whitleyi Iredale, 1938

Raja whitleyi Iredale, 1938, *Austr. Zool.*, 9, 2: 169. Type locality, Port Phillip, Victoria.

Raja whitleyi Iredale,. Scott, 1967, *Pap. Proc. Roy. Soc. Tasm.*, 101: 190 (synonymy).

Remarks.—In a previous contribution (1967)—in which it was observed that the nomenclature of this ray appears to have received more attention than its external features—it was shown that several characters commonly relied on to separate this species from *R. lemprièri* Richardson, 1848 are not constant; and an account of 3 males and 1 female was accompanied (table 1: 191) by a full set of measurements. An examination of 5 males and 12 females, taken during the St Helens Surf Angling Club's Championships at Swimcart Beach, near St Helens, Cornwall on 5 May 1968 provides useful data on individual variation in overall size and in relative development of certain features, and casts light on the question of possible differences in size and/or proportions in the sexes. Some dimensions of the females are set out in table 1 and of the males in table 2; in both cases expressed as millesimals of disc width.

In the present sample total length (measured in all females, in 4 of 5 males) ranges rather widely from 565 to 948; $\bar{x}$ 747.9±25.6, σ 102.3±18.1, V 13.7±2.4: the only specimen in the earlier sample with the tail tip not removed, a male, measured 695. For all 17 present specimens disc width ranges from 420 to 673; $\bar{x}$ 532.3±17.2, σ 70.7±12.1, V 13.3±2.3: corresponding values for the earlier sample being 454-603, $\bar{x}$ 501.5±30.4, σ 60.8±21.5, V 12.1±4.3.

An interesting qualitative individual variation is presented by the relation of the dorsals. In 1 of the 4 males in which the relevant region is intact and in 3 of the 12 females the bases of the fins are continuous, while all other individuals have an interdorsal interval of 4-12, modally 6, thousandths of disc width.

For all measurements recorded the coefficient of variation has been calculated; for ready assessment of the diagnostic reliability of the dimensions concerned these V values are recorded in the tables. Apart from the formally invalid V of 60.7 (males) 67.8 (females) for interdorsal interval, the values are seen to range from 1.1 to 13.3, with a mean of 5.9. Values of V of, say, $\leq$10 may in general be taken as indicative of tolerably constant body form: an arbitrary V=10.0 being exceeded here, and then but slightly, by second dorsal base (both sexes), length of ventral (both sexes), interorbital width (males).

Comparison of mean values in the tables reveals no noticeable differences between the sexes in relative magnitude of the dimensions recorded. Though mean absolute disc width of females, 542.4±22.0 (σ 76.3±15.6, V 14.1±2.9) exceeds that of males, 508.0±13.5 (σ 47.0±9.6, V 9.3±1.9) by 6.8%, and mean total length of females, 754.1±32.1 (σ 111.4±22.7, V 14.8±3.1) exceeds that of males, 729.25±32.4 (σ 64.7±22.9, V 8.9±3.2) by 3.4%, neither difference, in samples with such a high variance, is statistically significant—while, indeed, in the previous sample disc width of all 3 males (455, 498, 603) exceeded that of the single female.

TABLE 1

Raja whitleyi Iredale, 1936. Dimensions, expressed as thousandths of disc width, of 12 females from Swimcart Beach, near St Helens, Dorset, Tasmania, 5 May, 1958.

Dimension	Specimen: disc width, mm												$\bar{x}$	σ	V
	(*f*) 420	(*g*) 427	(*h*) 479	(*i*) 489	(*j*) 511	(*k*) 530	(*l*) 565	(*m*) 581	(*n*) 602	(*o*) 610	(*p*) 622	(*q*) 673			
Total length	1,345	1,436	1,392	1,403	1,354	1,342	1,515	1,377	1,342	1,395	1,408	1,409	1,393.2± 13.5	46.8±9.6	3.4± 0.7
Length to origin of first dorsal	1,157	1,204	1,201	1,188	1,132	1,151	1,242	1,208	1,151	1,148	1,119	1,193	1,174.5± 10.1	35.1±7.2	3.0± 0.6
Base of first dorsal	75	87	86	90	80	87	92	88	87	98	87	95	88.0± 1.5	5.2± 1.1	5.9± 1.2
Interdorsal	0	12	4	6	6	6	9	0	6	8	0	9	[5.5± 1.1]	[3.7±0.8]	[67.8±19.2]
Base of second dorsal	71	89	73	84	78	81	85	76	81	75	56	56	75.4±2.9	10.0±2.0	13.3± 2.8
Length to front of vent	733	771	756	740	750	743	788	749	743	736	751	755	751.3± 4.3	14.8±3.0	2.1± 0.4
Length of vent	33	40	46	49	41	47	39	43	47	39	43	37	42.0± 1.3	4.5±0.9	10.8± 2.2
Length to mouth	212	183	230	215	211	213	224	213	213	207	217	217	212.9± 3.1	10.8±2.2	5.0± 1.0
Width of mouth	129	150	134	137	149	147	140	136	147	136	130	135	139.2± 2.0	7.0±1.4	5.1± 1.0
Length to eye	233	265	253	227	237	240	248	246	240	218	240	241	240.7± 3.3	11.6± 2.4	4.8± 1.0
Interorbital	85	98	79	96	72	92	90	98	92	85	97	104	90.5± 2.4	8.3±1.7	9.2± 1.9
Length to first gill-slit	347	413	372	350	360	353	359	349	353	369	357	345	360.6± 5.3	18.5±3.8	5.1± 1.0

TABLE 2

Raja whitleyi Iredale, 1938. Dimensions, expressed as thousandths of disc width, of 12 females from Swimcart Beach, near St Helens, Dorset, Tasmania, 5 May, 1968.

Dimension	Specimen: disc width, mm					$\bar{x}$	σ	*V*
	(*a*) 457	(*b*) 464	(*c*) 495	(*d*) 548	(*e*) 578			
Total length	..	1,362	1,466	1,366	1,407	1,400.3±20.9	41.8±14.8	3.0± 1.1
Length to origin of first dorsal	1,179	1,149	1,168	1,174	1,149	1,163.8± 5.7	12.5± 4.0	1.1± 0.3
Base of first dorsal	..	95	87	79	94	88.8± 3.2	6.4±2.3	7.2± 2.6
Interdorsal	..	6	0	4	5	[3.8± 1.1]	[2.3± 0.8]	[60.7±28.2]
Base of second dorsal	..	65	81	80	66	73.0± 2.8	7.5± 2.7	10.3± 3.7
Length to front of vent	792	739	731	738	780	756.0±11.2	24.9± 7.9	3.3± 1.0
Length of vent	42	47	44	57	43	46.6± 2.4	5.5± 1.7	11.7± 3.8
Length to mouth	225	222	212	214	215	217.6± 2.2	5.0± 1.6	2.3± 0.7
Width of mouth	153	144	131	139	143	142.0± 3.2	7.2± 2.3	5.0± 1.6
Length to eye	256	239	235	251	228	241.8± 4.6	10.3± 3.3	4.3± 1.4
Interorbital	92	80	87	90	66	83.0± 4.2	9.4± 3.0	11.4± 3.6
Length to first gill-slit	374	384	362	372	352	368.8± 4.9	10.9± 3.5	3.0± 0.9

Family SYNGNATHIDAE

The Check-List (McCulloch, 1929) credits Tasmania with 7 species, the Handbook (Munro; cited, 1958) with 15. In a paper containing the first local record of *Syngnathus poecilolaemus* Peters, 1869, the writer (1968:4), listing 20 species, entered both *Hippocampus novaehollandiae* Steindachner, 1866 and *H. whitei* Bleeker, 1855, noting, however that Munro treats Steindachner's species as a synonym of Bleeker's—it seems clear this identification is to be accepted. With the addition below of the first notice from Tasmanian waters of a representative of the genus *Ichthyocampus* Kaup, 1853 the total for this State remains at 20.

A key to 17 Tasmanian species is given in Part X (1961:58). *Hippocampus whitei,* first reported from Tasmania (Port Arthur, Pembroke), by Whitley & Allan (1955:32), but not noted in the key, would enter it at couplet 15. From both the species diagnosed there, *H. abdominalis* Lesson, 1827, and *H. breviceps* Peters, 1870, it differs in having fewer dorsal rays (16-17; *cf.* 26-31, 19-22), fewer caudal rings (33-36; *cf.* 42-49, 38-42); it differs also from the former species in its shorter dorsal base (fin on 2-3+1 annuli; *cf* 2-5+2-5), and from the latter in its longer snout (2 in head, 3-3.5 eye; *cf.* 3 in head, 2.1 eye).

S. poecilolaemus would run down to couplet 9. Agreement with all entries in the second half of this couplet, except number of dorsal rays, would separate it from *S. mollisoni* in the first couplet. From both species in couplet 10 (to which couplet it would be referred, apart from dorsal fin count), namely, *S. curtirostris* Castelnau, 1872 and *S. phillipi* Lucas, 1891, it is distinguished by more numerous dorsal rays (26-29; *cf.* 20-24, 22-28), by much longer head (about 1.5 in trunk; *cf.* about 3, about 2); further from *S. curtirostris* by the keeled operculum.

From *Stigmatopora argus* (Richardson), 1840 and *S. nigra* Kaup, 1853—the only other Tasmanian pipefishes having the constellation of characters, TV continuous with CU, TL continuous with CL, TM ending free—*Ichthyocampus cristatus* may be recognised at sight by presence of caudal fin, fewer dorsal rays (26-27; *cf.* 43-58, 35-43), predorsal length about 4 (*cf.* 1-2) times dorsal base.

Genus ICHTHYOCAMPUS Kaup, 1853

Ichthyocampus cristatus McCulloch & Waite, 1918

Ichthyocampus cristatus McCulloch & Waite, 1918, *Rec. S. Austr. Mus.*, 1, 1: 40, fig. 26. Type locality, Spencer Gulf, South Australia.

Tasmanian record.—This species—reported in the Check-List only from South Australia: Scott (1962: 115) notes also Victoria—is here added to the Tasmanian list, a specimen having been collected on 20 July 1968 by Mr D. C. Wolfe by dredging, 400 yards south-east of the wharf at Lady Barron, Flinders Island, county Flinders.

Fin. counts and dimensions.—D.27. A.3? P.12 (left), 13 (right). C.8. Annuli 20+40; subdorsal 1.2+4.5. *Ls* 230.0, *Lt* 235.0. Some dimensions as *TLs*: head 70; snout 21; eye 13, orbit 17; interorbital 9; length to pectoral 79; length of pectoral 19, oblique pectoral base 8; length to dorsal origin 333, dorsal base 73; length of anal 5; length to vent 352; trunk 283; tail without fin 648, with fin 670; length of pouch fold 240 (left), 254 (right); depths (in parentheses widths) at points noted, middle of snout 17 (9), front of eyes 21 (13), back of eyes 22 (21), operculum 29 (21), vent 30 (22), middle of tail 17 (17); maximum 31 (34).

No data on fin counts or proportions other than those noted by Waite & Hale (1921: 304) for 4 individuals (longest 214) from Spencer and St Vincent Gulfs appear to have been published, their values being those given in the Handbook diagnosis (Munro, 1958: 88). For the ratios they record our values are as follows (South Australian data in parentheses): snout in head 3.27 (3.4);

eye in snout 1.63 (1.3), orbit in snout 1.23 (—); eye in head 5.33 (4.7), orbit in head 4.00 (—); head in trunk 4.06 (3.6-4.4); head in *Lt* 14.7 (13.3-15.3); trunk in tail without fin 2.29, with fin 2.37 ('in tail' 1.8-2.1).

Brood pouch.—The ovisac of the holotype was filled with well developed young, and covered 13 tail rings. In our example the pouch is open and empty; even when the folds, the free margins of which are rolled, are fully extended, they fail to meet in the middle: the pouch is clearly either not fully developed or is in course of regression. The folds begin at the front of the 1st caudal ring, just embracing here base of anal; they terminate, the right on 0.1, the left on 0.8, of the 15th caudal ring; without strengthening plates; hyaline, with a narrow irregular proximal band of brown chromatophores; with up to 10 longitudinal plicae. The pouch floor is covered with whitish somewhat opalescent integument, clearly traceable as such through the first 12 annuli, behind which the floor progressively approximates in texture and colour the general ventral surface of tail; through integument can be recognised the transverse ridges of the scutes; pouch shallowly divided into compartments by fusiform cross partitions, representing the element of scute sculpture described below under the name of escutcheon, but, being covered with smooth whitish integument, not exhibiting their tuberculate ornamentation.

External structure of scutes.—The sculpturing of the scutes in Tasmanian syngnathids has received but little attention: ornamentation of body scutes is diagnostic in *Solegnathus* Swainson, 1839, and the Handbook (Munro, 1958: 89) notes differences in the occipital scutes of 3 species; Günther (1870: 162, footnote) remarked of the primary pattern of ridges in *Leptonotus semistriatus* Kaup, 1853 'the bands are transverse (*fasciae*) and not longitudinal (*striae*)', and suggested emendation of the trivial name to *semifasciatus*; brief descriptions of the morphology of scutes have been given for that species (Scott, 1939: 145) and for *S. tuckeri* Scott, 1942 (1942: 18), while a more detailed analysis, recognising as chief motifs fan, double fan or spindle, rotula, festoon, has been made for *S. mollisoni* Scott, 1955 (1955: 133). The sculpturing in the present form is of considerable interest, both for its own sake and for its correlation with the distribution of certain elements of the colour pattern.

The following elements of sculpture are here recognised: (*i*) spindle, a group of small ridges, consisting of rows of coalesced, contiguous, or closely set minute granules, suggestive, typically, of a blunt karyokinetic spindle (the equator along main anteroposterior axis of fish), with at times some modification of the direction of the ridges, culminating in their subparallelism; (*ii*) fan or half spindle; (*iii*) barrel, a dolioform unit, comprising two fans representing the halves of two adjoining spindles, the ridges thus tending to converge at the middle of the unit; (*iv*) escutcheon, a small raised region, lozenge-shaped, fusiform, ovoid, or subcircular, here found separating spindles; (*v*) interstice, any area other than one of the four elements defined above.

In the specification of the sculpture pattern the following conventions and symbols are adopted. Standard symbols for body ridges are employed, namely, TU, TM, TL, TV for upper, middle, lower, ventral ridges, respectively, of trunk; CU, CL for upper, lower ridges of tail. Subscripts used are: s=superior, i=inferior, l=left, r=right. On-the-line symbols (other than those for ridges), with or without subscripts, if without parentheses refer to the trunk, if with parentheses to the tail. Spindles are denoted by capital letters, barrels by dashed capital letters, escutcheons by lower case letters. In numbering elements, the fish is viewed from the tail end, with head pointed away from observer; counting for spindles begins in trunk at TV, in tail at midventral line, for barrels at that crossed in trunk by TV, in tail by CL_l; counting proceeds clockwise.

The fact that the spindles present themselves as such obvious sculpture elements, and, moreover, have their poles located at the body ridges naturally suggests the formulation of an overall pattern in terms of them as definitive units—giving, for tail, 4 spindles, thus, from midventral line to CL_l, spindle half (A_l); spindle CL_l-CU_l, (B); CU_l-CU_r, (C); CU_r-CL_r, (D); CL_r-midventral line, (Ar); with, for the same regions, in that sequence, 4 escutcheons, namely (a_l), (b), (c), (d), (a_r): and for trunk 7 spindles, thus, TV-TL_l, spindle A; TL_l-TM_l, B; TM_l-TU_l, C; TU_l-TU_r, D; TU_r-TM_r, E; TM_r-TL_r, F; TL_r-TV, G; with 7 escutcheons, a-g, situated severally in the same regions, each apposed to a spindle. The arrangement of certain of the interstitial elements leads however, to a possible alternative pattern, the chief elements of which are the doliform units, barrels, each made of halves of adjacent spindles—giving, for tail, 4 barrels, thus, $(A^1)=(A_l)+(B_l)$; $(B^1)=(B_s)+(C_l)$; $(C^1)=(C_r)+(D_s)$; $(D^1)=(D_l)+(A_r)$; with 4 escutcheons, (a)-(d), their centres at barrel junctions: and for trunk 7 barrels, thus, $A^1=G_l+A_r$; $B^1=A_l+B_l$; $C^1=B_s+C_l$; $D^1=C_s+D_l$; $E^1=D_r+E_s$; $F^1=E_l+F_s$; $G=F_l+G_r$; with 7 escutcheons, a-g, their centres at barrel junctions. That this latter formulation, though probably not the morphologically prior one, can claim some validity beyond that dependent on selective visual susceptibility of the observer is evidenced by three considerations: (*i*) the nature and disposition of the interstitial elements, in particular the grooves, including an equatorial one found in all spindles (least developed in D); (*ii*) the nature of the barrel A^1, the ornamentation of which is essentially one of irregularly disposed granules, in marked contrast to the presence of well developed ridges in the adjoining A_l, G_r; (*iii*) the spatial correspondence obtaining, more or less precisely, between the main elements of colour pattern and the barrels rather than the spindles (see coloration, below).

A typical caudal scute comprises about a score of minute mammilate elevations so closely set as to suggest to the naked eye a continuous ridge; in a scute just behind brood pouch, median row with approximately 50 tubercles, number being less in scutes further back. In some trunk spindles, tubercles are fused basally; in some lines, or parts of lines, coalescent, their identity becoming virtu-

ally or entirely lost; least developed spindles B, F. On tail, escutcheons early elliptical or fusiform, the anterior border tending in annuli further back to become less strongly curved, the marking coming to approximate the shape of a bent bow; all somewhat elevated, (b) and (c) most noticeably so; extending anteriorly across about two-thirds, posteriorly about four-fifths, or more, of width of scute; anterior and posterior borders each delimited by narrow shallow groove, the two grooves, of which the anterior is usually the better developed, uniting at each pole of escutcheon, thence continuing, either as a groove (in (a) deep, forming nick at CL), or, in many cases in (b_s), (c), (d_s), as a grooved strap to scute border; covered with minute tubercles, similar to those of spindles, but mostly disposed irregularly, with in some scutes indications of a partial radial arrangement. Trunk escutcheons much like those on tail, similarly tuberculated, exhibiting parallel changes of shape according to position; posterior examples of c, e only half as long as, but subequal in width to, anterior examples of (b), (d); b, f smaller than c, e; d narrower, and in general more pointed, than c, e. Most noticeable interstitial elements of trunk are: a median depressed nonturberculate region between a and g, traversed medially by (the discontinuous) TV (here well elevated, but not traceable through most, in a few scutes all, longitudinal extent of A^1); a short wide deep groove running from outer pole of a and of g to meet, at a short keel on each TL, the corresponding groove descending from b and f; the grooves round b and f, which are deeper and wider than grooves round other escutcheons: in d the groove round the posterior border shows some obsolescence. the integrity of the element being maintained partly by its mere elevation.

Coloration.—Notes made after preservation for some time in alcohol. Lateral surface of trunk brownish the chief pattern being provided by the darker dolioform D^1, E^1 [*cf.* Waite & Hale, 'Each scute on the upper half of the body from the nape to the end of the tail with a grey ring which touches its fellow in the median dorsal line, the upper angle bisecting the rings'.]. Apart from a small non-tuberculate brownish or amber region before, behind, sometimes wholly surrounding, b, whole flank minutely, irregularly blotched, and on some ridges of B, F, and less markedly C, E, briefly lined with whitish; escutcheons lighter than spindles, b, f being less extensively, but somewhat more intensely, white than c, e; an extension of light colour of ventral surface to just above TV as a very narrow lower border to lateral surface, in each scute either with inferior margin continuous and superior margin of 3 upwardly convex arcs, or occurring as 3 barely separate more or less hemispherical tongues. Dorsal surface of trunk darker than lateral; contributing a moiety of the conspicuous pattern element of D^1, E^1; along TU an irregular series of whitish spots and small splashes, best developed in the anterior one-third. Ventral surface mainly silvery white; on last 5 rings, and less noticeably on right side of preceding half dozen, some sulphur yellow near external borders. Lateral surface of tail brownish, with some indications of darker pattern elements provided by (C^1), (D^1) [apparently conspicuous in Waite & Hale's material]; some whitish or greyish mottling, least developed on escutcheons; much the most conspicuous pattern element, a series of light fawn extensions from ventral surface, their convex superior borders reaching anteriorly rather less than, posteriorly just, halfway up the lateral surface, in general one to an annulus (in 5 cases on right, in 4 on left, matching 4 on right, virtually continuous across 2 rings), thus coming, apart from exceptions noted, to coincide in extent, in posterior part of tail, with ($A^1{}_s$), ($D^1{}_i$); units separated, along CL, by short vertical strokes of brown, located on the lower angles of (b), (d), and in the adjoining grooved interstitial region; these short strokes just extending, occupying interstitial groove, on to ventral surface, which is otherwise immaculate light bright fawn. Dorsal surface of tail much like that of trunk.

Head: except for white markings noted below, whole preorbital head very dark, almost black, postorbital portion brown on lateral surface, darker on dorsal surface, whitish with some sulphur yellow on ventral surface; small white patch on each side just below angle of gape; 3 white ovoid spots from inferior border of orbit, the largest reaching lower border of face; 2 apposed white spots in midventral line of middle of snout; lower one-third of operculum continuous with light ventral surface, rest crossed by 10 imperfect subhorizontal lines, of which 5th from bottom expands in its posterior two-fifths, a row of 6 white dots below lowest line; supraorbital ridges, rostral ridge near its junction with them, a short narrow median interorbital stripe, and a fine median line from shortly behind eye to middle of nape, all silvery white. Dorsal fin dirty whitish, 1st ray wholly white; beginning immediately behind this and covering next half dozen rays and their membrane a conspicuous black blotch. Caudal light brownish, somewhat darker at tips of rays. Pectoral pale golden; narrow oblique brown bar near base of rays; all of 1st (uppermost) ray, most of 2nd ray, membrane between them, and proximal half of membrane between 2nd and 3rd rays black. Anal colourless.

Family MACRURIDAE

The adoption of the name Macruridae for this family here—and in, *e.g.*, Munro (1957), Scott (1962)—follows Berg (1947), who subsumes in it Macrouridae and Coryphaenoididae, the former occurring in the Check-List (McCulloch, 1929) and widely in Australian and New Zealand works up to, and beyond, that date (including Part VI of the present series), the latter being met with in, *e.g.*, McCulloch (1926), Whitley (1968).

The Check-List records from Tasmania: (*i*) *Coelorhynchus australis* Richardson, 1839 [the original spelling of Giorna's genus is *Coelorinchus*, given in the Check-List as *Coelorhinchus*: the original orthography is retained by Whitley (1968); usually amended as here]; (*ii*) *Lepidorhynchus denticulatus* Richardson, 1846; (*iii*) *Macruronus novaezelandiae* (Hector), 1871; with (*iv*) *C. mirus* McCulloch, 1926 listed from Bass Strait (and New South Wales). Munro (1957: 60) adds Bass Strait to the range of (*v*) *C. innotabilis* McCulloch,

1927 (described from New South Wales). The present communication proposes the rehabilitation of (*vi*) *C. mortoni* Ogilby, 1897, sunk in the Check-List in the synonymy of *C. australis*, and since generally abandoned.

A key to the Australian Macruridae has been given earlier (Scott, 1953: 150): 9 species are referred to in that paper, but in their enumeration, as printed, the sixth entry, *C. fasciatus* (Günther), 1870, has inadvertently been dropped out (this species, however, duly appears in the key). The separation of *C. mortoni* from other members of the genus is discussed below.

Genus **COELORHYNCHUS** Giorna, 1809

Coelorhynchus mortoni Ogilby, 1897

(Fig. 1)

Coelorhynchus mortoni Ogilby, 1897, *Pap. Proc. Roy. Soc. Tasm.*, 1896: 83. Type locality, Estuary of the Derwent River, Tasmania. ['Type destroyed' (McCulloch, 1929: 127)].

Coelorhinchus australis (Richardson). McCulloch, 1929, *Mem. Austr. Mus.*, V: 127, *partim. Non Lepidoleprus australis* Richardson, 1839, *Proc. Zool. Soc. Lond.*, vii: 100—type locality, Port Arthur [Pembroke], Tasmania.

Material and localities.—(*a*) Complete specimen, *Ls* 509, *Lt* 514, taken in 100 fathoms off Bicheno, Glamorgan, on a long-line set for trevally in mid-1967; (*b*) complete specimen, *Ls* 508, *Lt* 513, captured in a shark net in 60 fathoms, south of Pedra Branca, on 9 June 1968 by Dillon Brothers on *Savarus;* (*c*) head only of fish taken on a shark long-line in 100 fathoms, south of South West Cape, Kent, in mid-June 1968 by R. Petman on the *James Leigh*—all material made available for examination by Mr D. C. Wolfe. Specimens (*a*) and (*c*) will be deposited in the Tasmanian Museum, Hobart, specimen (*b*) in the Australian Museum, Sydney.

Description.—Where a statement in this account, verbal or numerical, has two values, the first relates to the larger individual, (*a*), the second to (*b*): unless otherwise indicated, single statements are applicable to both complete examples (only): a few entries referring to (*c*) are so specified.

D. ii, 10; 76: ii, 9; 75. A. 79, 81. V. 7. P. 17 (left), 16: 16, 16. C. 6. Br. 6. L. lat. 106: 108. Sc. tr. 4/1/14; 4/1/9 (obliquely back from origin of first dorsal, from origin of second dorsal). Gillrakers 2+5 (second arch).

Head 4.80, 5.35, trunk 8.78, 8.61, tail 1.47, 1.44, in *Ls*.

Head and trunk stout, lowest point at vent, highest at first dorsal origin; tail in lateral view tapering evenly caudad, progressively compressed to a terminal thickness of about a millimetre. Vent below early part of interdorsal. Maximum depth, found near pectoral origin, 6.61, 6.60, depth at vent 7.59, 7.36, in *Ls*. Maximum width, found near middle of ventrals, 8.48, 8.06, width at pectoral origin 8.93, 8.76, in *Ls*; width at middle of anal 1.79, 1.88 in *Ls*, or 2.33, 2.16 in depth there.

Head subconical: dorsal profile moderately convex forward to near middle of eye; then slightly and briefly concave; shortly convex above nostrils; virtually straight, gently convex, to tip of snout: ventral profile increasingly curved up to mouth; between upper lip and tip of snout slightly concave, the general direction here at about 45° to anteroposterior axis of fish. Snout pointed: tip of upper jaw slightly produced as a blunt rostral tubercle, its length less than half its basal width; rather more pronounced in (*a*) and (*c*) than in (*b*); its inferior surface elevated, strongly spinose. Eye large, not cutting profile; elliptical, its transverse 1.35, 1.24 [(*c*) 1.41] its vertical diameter; its transverse diameter 3.23, 3.33, that of orbit 3.07, 3.06, in head; snout tip to orbit less than (1.10, 1.17; (*c*) 1.07 in) orbit, and less than (1.03, 1.02 in) [(*c*) equal to] transverse eye; snout tip to eye less than (1.06, 1.07; (*c*) 1.03) in orbit, equal to or barely exceeding (1.02) [(*c*) 1.06] transverse eye. Interorbital 1.08, 1.02 [(*c*) 1.09] in eye, transversally flat for virtually whole extent near middle of eye; behind this, about to posterior border of orbit, a central flat platform, bordered on either side by a barely concave oblique strip, widening posteriorly and becoming continuous behind with the upper larger moiety of lateral slope of occiput. Posterior nostril large, immediately in advance of orbit, at 8.30, 9.30 o'clock (left side of fish viewed); subelliptical, sloping downward and forward, its length about thrice its width, subequal to its direct distance from rostro-infraorbital ridge. Anterior nostril subelliptical, about half as long, nearly as broad, as posterior, set against middle half of latter, separated from it only by a flat common fleshy rim. Supraorbital ridge low, best developed immediately behind posterior nostril, ceasing near horizontal level of bottom of latter. Suborbital ridge inconspicuous, low, acute, spinose. Well developed supranarial ridge, coalescent behind with supraorbital ridge, running forward as upwardly convex arc to join rostro-infraorbital ridge a little below level of inferior orbital rim; constituting superior and anterior border of an ovoid shallow fleshy narial basin, bounded below by less developed ridge: from upper end of this ridge a genal ridge, best developed in (*c*) least in (*b*), down and back between orbital rim and rostro-infraorbital ridge, nearer latter for most of its length, becoming confluent with it behind level of orbit: a fine ridge, involving only 3-4 scales, behind and just above point of confluence. Low but distinct median ridge from rostral tubercle to just beyond level of front of eye; region between this and supranarial ridge slightly concave. In (*a*) dorsum and sides of postorbital head strongly rounded, presenting a virtually continuous arc, obscurely divisible into 8 flattish platforms, delimited by 7 ridges: median ridge detectable, rather as low mounding than true ridge, only in anterior half of interval between level of eye and origin of dorsal; on each side a ridge from posterosuperior angle of orbit, where it is subcontinuous with supraorbital ridge, obliquely back to upper angle of operculum; above last-named a sinuous ridge joining a point shortly above middle of orbit to beginning of lateral line; above this on each side a ridge with anterior origin subcontinuous with that of last-named ridge, extending, gently convex upwardly, to back of head, the pair furthest apart posteriorly, their interval there

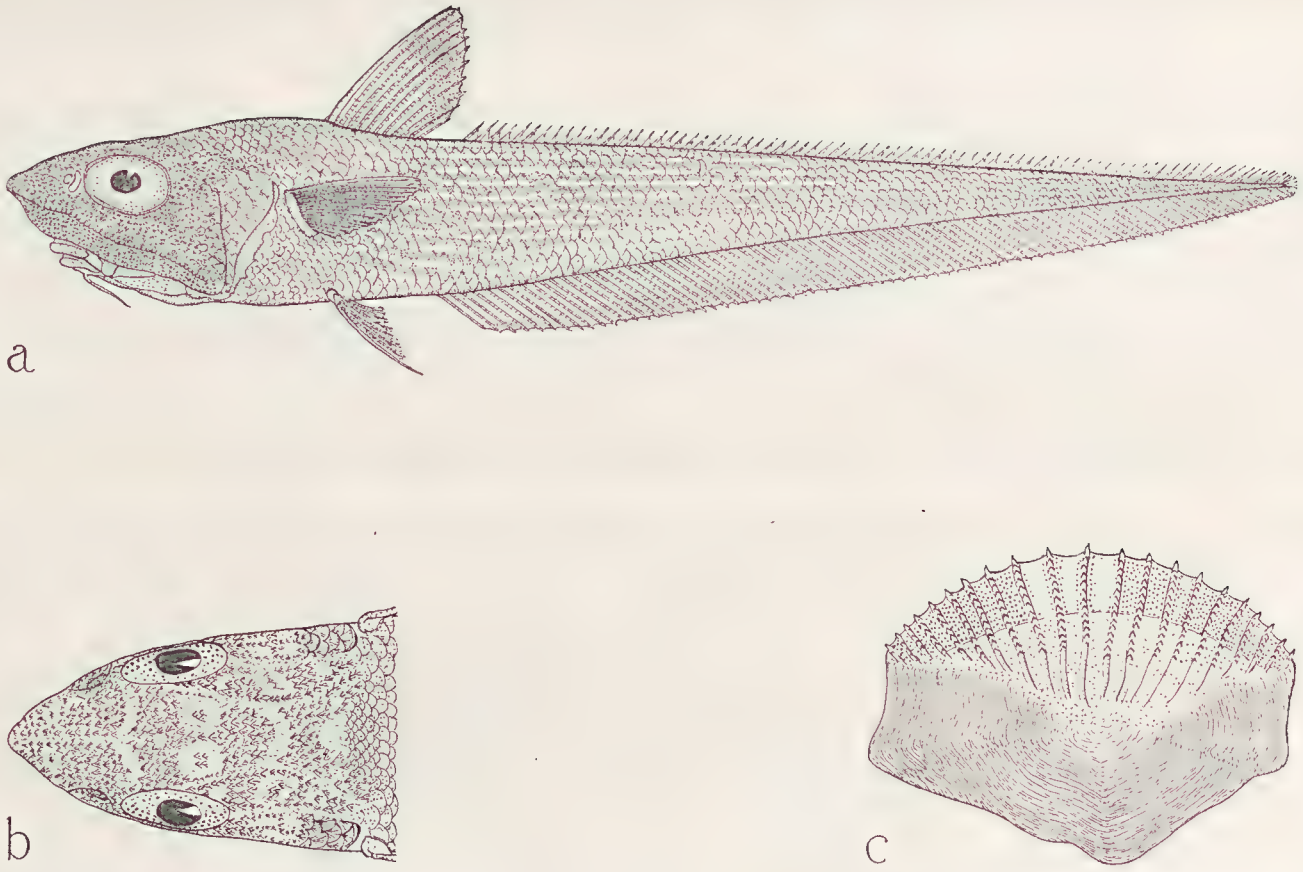

FIG. 1.—*Coelorhynchus mortoni* Ogilby, 1897. *a.*—Lateral aspect of a specimen, 514 mm in total length, caught off Bicheno, Glamorgan, Tasmania, in 100 fathoms; x ⅓. *b.*—Dorsal aspect of head of a specimen, 513 mm in total length, caught off Pedra Branca, south of South East Cape, Kent, in 60 fathoms, showing colour pattern (not indicated in *a*); x ½. *c.*—A scale from flank below interdorsal; x 5½.

two-thirds orbit: in (*b*) platforms and ridges less pronounced, except last-described ridges, which are prominent. Rostro-infraorbital ridge prominent, slightly sinuous, with three main forward and downward convexities; extending from rostral tubercle to just short of preoperculum, ending in a flattened downwardly and backwardly directed projection; subcontinuous here with lower end of poorly developed ridge, obsolescent superiorly, along preopercular border; main ridge comprising some two score scales, each with backwardly diverging fan of striae, most terminating in spines; scales separated by grooves normal to general direction of ridge, resulting in a crenulate or subcrenulate border; at about half a dozen scales behind rostral tubercle main exposure of scales briefly descends, on each side of head, on to lower surface of snout, forming a revetment of 4-6 scales.

Mouth undershot; length to its origin (a little in advance of level of front nostril) 5.89, 5.28 in head, 2.11, 1.78 in its width measured between outer borders of maxillae: lower jaw wholly received into upper. Maxilla to 0.6, 0.7 eye; lateral border of mandible to 0.95 eye, to past eye by 0.1 eye, inferior border to 0.3, 0.4 eye beyond eye. Whole external surface of lower lip, more than half external surface of upper lip, internal surface of both lips, highly papillate, complex, particularly in (*b*) and (*c*), each papilla with up to half a dozen distal processes or lobules. Mental barbel a simple short filament, becoming regularly more slender distally; length 1.22, 1.03 preoral length, subequal to interdorsal. Operculum subtriangular, posterior border markedly concave; inferior angle a rounded point continued as a small membranous lobe. In front half of upper jaw a rather narrow band of villiform teeth, anteriorly in 4-5 tolerably regular series, posteriorly becoming rather more irregular. Whole length of lower jaw to gape with villiform teeth in a band, widest anteriorly, width exceeding greatest width in upper jaw, 5-6 rows here, decreasing behind to a couple of closely set irregular rows; whole series one-third longer than that of upper jaw. Palate and tongue edentulous. Save in immediate vicinity of nostrils (very small fraction of narial basin) whole of head above rostro-infraorbital ridge scaly. Scales on operculum and most of preoperculum approaching in size trunk scales, and not notably more spinose, but with carinae radiating instead of being subparallel: rest of lateral surface of head with smaller scales of variable size, smallest in narial basin and in vicinity of orbit, virtually all spinose, most very spinose: dorsum of head with closely set smallish scales, nearly all intensely, many quite complexly, spiny. Whole oblique strip bounded above by rostro-infraobital ridge, below by mouth and by backward extension of line of mouth, granulate, minutely spinulose, spines directed backwards, the feel being velvety or prickly according as finger is drawn across it from or towards snout tip. About posterior two-thirds of pennon-like ventral surface of mandible similarly rugose, slightly spinulose, except narrowly along its borders: rest of inferior surface of head smooth, fleshy. Branchiostegals 6; membranes united briefly anteriorly across the isthmus. Gillrakers on second arch 2+5; low spinulose mounds, those on upper limb closely set, those of lower arch further apart, interval at middle of series somewhat exceeding basal diameter of raker. A membrane, widest above, connecting first gill-arch with inner side of cheek, and greatly restricting opening of first gill-slit. Pseudobranchiae rudimentary. Trunk and tail covered with scales, except on pectoral and ventral bases, in a median sulcus, about one-third as long as ventral fin, extending forward from vent, and along a slip, widest anteriorly, bordering anal on each side. Each body scale with, usually, 18-22 (some near end of tail as few as 12) subparallel keels, each consisting of some minute but strong, acute, decumbent, backwardly overlapping spines, the distal spine projecting beyond general free border of scale, this border continuously rounded, not scalloped between carinae. Each lateral line scale with a median groove, partly or wholly glazed white, dividing the ridges into two sets, and continued back, as a fleshy connexion, to next scale. Lateral line with 106, 108 scales; originating about midway between dorsal profile and upper angle of operculum; running back and down, approximately in a straight line, to about $1\frac{1}{4}$, $1\frac{1}{2}$ times head behind head, *ie.*, to about 30th tubercle, being here about half as far again from ventral as from dorsal profile; thence running virtually straight back, remaining throughout somewhat nearer to dorsal than to ventral profile.

First dorsal ii+10, ii+9; 1st spine minute, largely embedded, full length (4.0, 3.8 mm) revealed only by dissection, in (*a*) spine-like, acute, in (*b*) massive, obtuse; contiguous with base of next spine; 2nd element non-sepate, unbranched, spinous, smooth; remaining elements septate, branched rays; length of spines 26..5, 25.0; 1.59, 1.42, in head; lengths of rays 1.56, 1.41; 1.59, 1.46; 1.66, 1.61; 1.77, 1.79; 2.08, 2.16; 2.49, 2.57; 2.90, 3.25; 3.37, 4.42; 5.05, 5.46; 1.01, —, in head; fin originating above hind border of pectoral base; length to its origin 3.95, 4.27 in *Ls*, 1.22, 1.25 head; base 3.17, 3.31 in head; laid back, 2nd ray reaches 4th, 3rd ray of second dorsal, last ray falls short of, penultimate ray reaches, 1st ray of second dorsal. Interdorsal 5.58, 4.32 in head, about 3/5, 3/4 eye. Second dorsal 76, 77; very low; 1st and 2nd rays equal, 3rd a little longer, in (*a*) increasing slightly to about 10th then decreasing slowly, in (*b*) decreasing to about 10th, remaining constant to about 40th, then decreasing slowly backward; lengths of 1st, 2nd, 3rd, 10th, 20th, 30th, 40th, 50th, 60th, 70th, last rays 10.8, 8.64; 10.8, 8.64; 10.6, 8.56; 10.2, 9.50; 11.2, 9.50; 12.9, 9.50; 13.1, 9.50, —, 9.60; —, 10.4; 14.7, 13.6; 15.4, 14.0, in head; originating above interval between 3rd and 4th anal rays; length to origin 2.80, 2.99 in *Ls*. Anal 79, 81; well developed; longest ray 1.0, 1.4 eye; lengths of 1st, 2nd, 3rd, 10th, 20th, 30th, 40th, 50th, 60th, 70th, last rays 4.71, 4.08; 4.00, —; 3.80, 3.24; 3.29, 2.72; 3.24, 2.64; —, 2.57; 3.31, 2.47; —, 2.94; 3.94, 3.53; 5.30, 5.00; 7.85, 7.92, in head; length to origin 2.99, 3.12 in *Ls*. Pectoral 17 (left), 16 (right), 16, 16; small, subequal to head behind middle of eye; pointed; 1st (uppermost) and last 3-4 rays not, or barely, split, remainder feebly divided; 1st ray 1.05, 1.02 in longest (3rd), which is 2.19, 1.77 in head; whole fin 1.89, 1.73 in head; extending to level of end of vent. Ventral 7;

smaller than pectoral, a little more than post-orbital head; pointed; 1st (outermost) ray prolonged, reaching to anal origin; 1st ray simple, rest well divided; lengths of rays 2.35, 2.24; 2.92, 2.57; 3.03, 2.67; 3.21, 3.07; 3.37, 3.22; 3.53, 3.41; 3.90, 3.67, in head; whole fin 2.19, 2.07 in head; originating below hind border of pectoral base; length to origin 4.04, 4.64 in *Ls*. Caudal 6; minute; confluent with dorsal and anal.

General colour of trunk and tail in (*a*) medium greyish brown above and on upper part of sides; about lower one-third of flank, as far back as, perhaps beyond, last one-fifth of anal base, lighter brown, this extending, with some lightening, on to ventral surface: in (*b*) upper colour somewhat lighter brown, lower dirty whitish: both fish with some metallic lustre, due to presence of a short bronze streak on posterior part of all, or most, of keels of scales. On whole body, each scale with a medial white bar, covering from about one-fourth to about one-third of its exposed vertical extent, the white more intense, somewhat wider, near embedded margin; these markings giving rise to subcontinuous or continuous white lines, presenting, on whole of upper and anterior part of lower region of flank, a conspicuous pattern. Four such lines on the four rows of scales above lateral line (itself white), 1st starting behind dorsal base and extending back, flanking second dorsal, for about one and one-third head-lengths; 2nd, 3rd, 4th originating behind head, extending, like 1st, through full length of scale series, 2nd reaching extinction approximately a head-length before tail tip. While all body scales, even on ventral surface, have their median region lighter, on only about 8 of the lateral scale series below lateral line do these constitute a conspicuous, contrasting white line, even then only, among the lower series, in their anterior portion. In (*a*) most of hard part of head more or less concolorless with trunk; operculum and most of preoperculum darker; behind eye, and, continuing in same vertical line, below it, an obscurely delimited somewhat pinkish bar; narial basin whitish, somewhat dusky; tuberculated strip below ridge from rostral tubercle to near preopercular angle fawn, lightest round mouth, dusky near snout tip; tuberculated area on mandible dirty whitish; lips fawn; barbel pale yellowish; branchiostegal membrane flesh-coloured: in (*b*) head in general decidedly darker than trunk; darkest on dorsum, here approaching black; an ovoid light patch behind and below eye; rest of cheek somewhat darker than opercle; narial region, tuberculated areas, barbel, lips, branchiostegal membrane much as in (*a*). Both specimens, also (*c*), with light markings on upper and post-orbital lateral surface of head and on nape. In (*b*) these markings constituting an ornate conspicuous pattern of white and pale fawn (fig. 1b) symmetrically disposed as follows: on dorsum (*i*) a pair of small circles on snout, interval between them subequal to their distances from snout tip and anterior nostril; in interorbital space (*ii*) wide, forwardly directed chevron over, projecting a trifle in advance of, front one-fifth of eye; (*iii*) two contiguous circles occupying two-thirds of head width above about last half of eye; (*iv*) between (*ii*) and (*iii*) a median spot; (*v*) above orbit, external to, posteriorly level with back of, each item of (*iii*), a double (left), treble (right) spot; on median platform of occiput (*vi*) a pro-concave arc, its chord subequal to its distance from orbit, about two-thirds eye diameter; on each side of occiput (*vii*), external to, extending well in front of, reaching a little behind, (*vi*), a curved loop, convex upward and forward, (*viii*) and (*ix*), directly behind (*vii*), two markings, on right side forming clear, on left imperfect, circles, the hinder, (*ix*), the larger, its posterior border about level with middle of hind border of operculum; (*x*) at junction of head scales and trunk scales, a median circle with central spot, its distance from base of dorsal equal to its oblique distance from orbit; between (*ix*) and (*x*), a spot, (*xi*), double on left side; on lateral surface behind eye, a vertical series of three closely set markings, (*xii*), (*xiii*), (*xiv*), tending on left side to constitute circles; (*xv*), immediately behind uppermost, (*xii*), of last three markings, shortly in advance of antero-superior angle of operculum, a circle: also, on operculum 3-4 scales lighter than rest, whitish; on preoperculum 6-8 scales lighter than rest, mainly yellowish green, several with pinkish tinge. In (*a*) this complex pattern less clearly, less fully developed. In (*c*) all preserved part (most of dorsum behind eye missing) conspicuously patterned with whitish as in (*b*), except that markings (*i*) are arcs, not circles; markings (*xii*)-(*xiv*) represented by general subvertical bar, adjacent (*xv*) remaining distinct.

First dorsal with minute 1st spine hyaline, 2nd spine pale greyish, rays dark greyish basally, becoming brownish distally; basal half of membrane hyaline, with minute sparse dark punctulations, particularly adjacent to rays, distal half heavily punctulated, dusky. Rays of second dorsal with base either almost wholly black, or dark grey, narrowly bordered with blackish; tips whitish; membrane apparently vestigial, grey. Anal rays for most of their length slaty, darkening to brownish caudad; anteriorly with small brownish dots and splashes that progressively give way caudad to very closely set minute punctulations; bases of rays, pterygiophores and depression in which they lie all white; tips of rays mostly whitish; membrane largely greyish with distal duskiness anteriorly, duskiness increasing caudad to involve virtually whole membrane. Pectoral base whitish externally, approaching black internally; external surface of rays pale grey, internal surface of all except lowest 3-4 (which are white) dark brown; membrane white. External surface of prolonged ray of ventral white, of other rays slate; internal surface of rays, except prolonged ray, which is pale grey turning white distally, exhibiting, in obscure succession from base, blackish, dark brown, light grey, slate, light grey; membrane grey; rays and membrane with small dark brown spots and with minute dark peppering.

Dimensions as TLs.—Some dimensions of the two complete individuals examined are set out in table 3.

Discussion.—The history of *Coelorhynchus mortoni* Ogilby, 1897, type locality, Estuary of the River Derwent, has largely been one of taxonomic neglect or rejection. Not noticed in Lord (1923)

or Lord & Scott (1924), and not represented in the key to Australian and New Zealand species of the (relevant) subgenus *Paramacrurus* as there interpreted in the *Endeavour* Report of 1926 (McCulloch: 176), it was relegated by McCulloch in the Check-List (1929: 127), and earlier (1911: 38), to the synonymy of *C. australis* (Richardson), 1839, which also has Tasmania as type locality (Port Arthur [Pembroke]).

In instituting a direct comparison between his material (a specimen 520 mm long) and *C. australis*, Ogilby (giving values for Richardson's species in parentheses) deals with several characters that call for notice here: 'the much greater size of the head, the comparative measurements being 4⅓ and (nearly 5) in the total length'; no significant difference obtains here, the '4⅓', given earlier as '4½', being indistinguishable from the 4.4 for *C. australis* noted by Munro (1957: 61); in our specimens head is smaller than any of these being 4.85, 5.40 in *Lt*: 'the much smaller number of rays in the second dorsal, 68 (88), and anal 71 (87-96) fins'; our counts, 76, 77 and 79, 81, are intermediate: 'the much larger scales, 88 and (ca 130)'; again our counts, 106, 108, are intermediate: 'the different pattern and strength of the scale armature, for while the number of keels present on each body scale in *C. mortoni* is from 18 to 23, and these are arranged in parallel series and terminate each in a strong, free spine, which conjointly form the posterior border of the scale, in *C. australis* there are only 12-18 rows of keels and the border of the scale is more or less scalloped in appearance'; scales of our fish (fig 1c) conform wholly to the specifications of those of *C. mortoni*, and differ from those thus given for *C. australis* and from the figure by Waite (1911, fig. 1).

Two important resemblances to *C. mortoni*, and therewith contrasts to *C. australis*, exhibited by the present material are those of size of snout and colour pattern. Ogilby observes of snout 'a little longer than the eye': with 'eye' taken here as soft or true eye, our specimens have snout 1.00, 1.02 eye; whereas in *C. australis* snout is decidely greater than (≧1⅓) eye. *C. australis* is in general light grey, with some rather broad oblique dark bands on the upper side, two being most constant and best defined, the first immediately in advance of first dorsal, the second below the front part of the second dorsal; a blue black line runs along at least the hinder half of the dorsal and anal bases. Ogilby's colour note reads, 'Dark brown above, lighter brown below, all the darker scales with a whitish oblong spot at their base'; such white markings are well developed in our specimens, forming a striking series of more or less continuous white lines, very apparent on all darker parts of the body. The light coloured pattern on the head is a prominent feature in our examples. In respect of characters dealt with in Ogilby's account but not mentioned above, *e.g.*, cephalic ridges, location and size of fins, agreement with the present material is in general satisfactory: exceptions include more slender body here, 6.68, 6.66 (*cf.* 5½) in *Lt*; laid back 2nd ray of first dorsal reaching 3rd ray of second dorsal (*cf.* not reaching fin); presence of minute anterior spines of first dorsal (overlooked in Ogilby's specimen?), and fewer following rays, 10, 9 (*cf.* 13).

The first dorsal is noted by Ogilby as being inserted 'immediately behind the base of the pectoral'; an observation reasonably applicable to all members of the genus. However, a quantitative specification in terms of orbit-dorsal interval provides a useful character: in *C. australis* the dorsal begins 'one and a half diameters behind the orbit' (Waite, 1911: 177; and so figured by him, pl. XXIX, fig. 1): in our fish the interval is two diameters (1.98, 2.16). In Waite's figure of *C. australis* the mouth, as determined by the front of the upper lip, is shown extending forward to level of junction of nostrils, the preoral length being approximately 3.2 in head: in our specimens the lip extends well in advance of nostrils, preoral length being 5.3, 5.9 in head.

Overall the present fish thus exhibit significant differences from descriptions of *C. australis*, and good agreement with Ogilby's account of his material. It is concluded that *C. mortoni* Ogilby, 1897 is a valid species, and that these specimens are to be referred to it.

The Australian and New Zealand species can be separated thus.

KEY TO AUSTRALIAN AND NEW ZEALAND SPECIES OF *Coelorhynchus* Giona, 1803

1	Anal and second dorsal subequal in height. Snout conical, ending in a spine	Depth small (≐10-12 in *Lt*).	*C. innotabilis*
	Anal distinctly higher than second dorsal. Snout not conical, not ending in a spine	Depth moderate (≐5.7 in *Lt*).	2
2	Lower surface of head with asperities. Head close-set	Scales on upper surface of	3
	Lower surface of head almost or entirely naked. Of head spaced	Scales on upper surface	5
3	Interdorsal <½ (≐⅓) base of first dorsal. dorsal and lateral line ≧5½. Black bar rays	Scales between tip of adpressed along anal crossing middle of	*C. aspercephalus*
	Interdorsal >½ (0.6-1.1) base of first dorsal. dorsal and lateral line <5½ (3½-4½).	Scales between tip of adpressed No such black bar	4

4	Dorsal origin behind orbit by <2 (≐1½) orbit. Snout >eye. Length to mouth <4 (≐3.0-3.5) in head. Scales with 12-18 carinae; hind border of scale scalloped between pointed tips of keels. Light grey; at least 2 oblique dark bars (near origins of dorsal fins; no white lines on flank	*C. australis*
	Dorsal origin behind orbit by ≐2 orbit. Snout <eye. Length to mouth >4 (5.3-5.9) in head. Scales with 18-23 carinae; hind border of scale not scalloped between pointed tips of keels. Brownish, no dark bars; conspicuous white lines along flank	*C. mortoni*
5	Interdorsal ≐ base of first dorsal. Eye > postorbital head. No scales on lower surface of head. Dorsal origin above 4th-6th anal ray. Second dorsal very low posteriorly, almost obsolete anteriorly. Whitish; some dark cross bars	*C. fasciatus*
	Interdorsal >(≐2) base of first dorsal. Eye ≤ postorbital head. Some scales on lower surface of head (behind angle of mouth). Dorsal origin above 8th-9th anal ray. Second dorsal low, tolerably even in height throughout. Uniform grey; small black spot on pectoral	*C. mirus*

The description of the New Zealand *C. oliverianus* Phillipps, 1927 does not include data to permit the making of the choice presented in couplet 2 of the above key. If the fish satisfies the first entry of that couplet, one is led, through 3 (by disagreement with the first 2 entries for *C. aspercephalus*) to 4; from both species of which it is distinguished by more attenuate form, depth at 35th anal ray being 25 (*cf.* 15-18) in *Lt*, by having snout 1.7 (*cf.* 0.8-1.4) in orbit, pectoral, ventral extending to 3rd ray, 2nd ray, respectively, of second dorsal (*cf.* neither reaching that fin). If it satisfies the second entry of couplet 2, one is led directly to couplet 5, where it is found to differ from *C. fasciatus* in its higher second dorsal, in head 'a little under 5' (*cf.* 3.8) in *Lt*, depth at dorsal origin 7.1 (*cf.* 5-6) in *Lt*, and apparently in colour pattern, and from *C. mirus* in respect of the first 2 specifications in the key.

TABLE 3

Coelorhynchus mortoni Ogilby, 1897. Dimensions, as thousandths of standard length (*TLs*), of 2 specimens, (*a*) *Ls* 509 mm, *Lt* 514, (*b*) *Ls* 508, *Lt* 513, from off Bicheno, Glamorgan, and south of Pedra Branca, Tasmania.

Dimension	(*a*)	(*b*)
Total length	1010	1010
Length to origin, termination of first dorsal	253, 319	234, 291
Length to origin of second dorsal	357	335
Length to origin of anal	335	321
Length to origin of pectoral, length of pectoral	218, 110	195, 108
Length to origin of ventral, length of ventral	248, 95	216, 91
Lengths of spines of first dorsal	8, 131	7, 132
Lengths of rays of first dorsal	134, 131, 125, 117, 99, 83, 72, 62, 41, 21	133, 128, 116, 104, 85, 73, 57, 51, 34
Lengths of 1st, 2nd, 3rd, 10th, 20th, 30th, 40th, 50th, 60th, 70th, last ray of second dorsal	19, 19, 20, 20, 19, 16, 16, —, —, 14, 14	22, 22, 22, 20, 20, 20, 20, 19, 18, 14, 13
Lengths of 1st, 2nd, 3rd, 10th, 20th, 30th, 40th, 50th, 60th, 70th, last ray of anal	44, 53, 55, 63, 63, 63, 63, 53, 53, 41, 27	46, 54, 57, 69, 71, 73, 76, 64, 52, 37, 24
Lengths of 1st, 3rd (longest) pectoral ray..	95, 100	95, 96
Lengths of ventral rays	88, 71, 69, 65, 62, 59, 53	84, 73, 70, 61, 58, 55, 51
Length to middle of vent	322	307
Head	208	187
Snout to orbit, to eye	62, 64	55, 57
Transverse diameter of eye, of orbit	64, 68	56, 61
Vertical diameter of eye, of orbit	47, 47	45, 45
Interorbital	59	55
Length to mouth, full width of mouth	35, 75	35, 63
Length of mental barbel	43	36
Maximum depth, maximum width	151, 116	152, 124
Depth, width at vent	132, 106	136, 112
Maximum depth, maximum width, of head	143, 112	144, 114
Depth at front, at back of eyes	90, 132	85, 118

Family APOGONIDAE

Genus **VINCENTIA** Castelnau, 1872

Vincentia lemprièri (Johnston), 1883

Apogon lemprièri Johnston, 1883, *Pap. Proc. Roy. Soc. Tasm.* (1882): 142. Type locality: Dunkley's Point, Sandy Bay [Buckingham], Tasmania.

Apogon lemprièri Johnston. Lord & Scott, 1924, Synopsis Vert. Anim. Tasm.: 10, 55. McCulloch, 1929, *Mem. Austr. Mus.*, V, 11: 172.

Vincentia novaehollandiae (Valenciennes), 1832. Munro, 1960, Handbook Aust. Fish.: 144, fig. 901 [*in Fisheries Newsletter*—now *Australian Fisheries*—XIX, 2: 20, fig. 901], *partim*.

Vincentia lemprièri Johnston, 1883. Scott, 1964, *Pap. Proc. Roy. Soc. Tasm.*, 98, 99, fig. 1.

New material.—Johnston's species has been discussed, redescribed and figured by the writer (1964), the material on which the account was based consisting of 2 specimens of *Ls* 68.0, 73.0, *Lt* 86.9, 91.1, both from George Bay, near St Helens, Cornwall. An additional example, *Ls* 34.0, *Lt* 37+ (imperfect), collected by Mr J. Singline, St Helens (received May 1969) exhibits the separation of the two dorsals noted earlier as constituting the main difference between *V. lemprièri* and *V. novaehollandiae*, of which latter Munro (1960: 144)—who sinks in it Johnston's species—observes 'Dorsal fins united at least basally', the figure reproduced showing the attachment of the membrane of the first dorsal extending up the spine of the second dorsal for about one-third the spine length. In the present specimen the membrane fails to reach the base of the second dorsal spine by 0.9 mm. A wider interorbital region in *V. lemprièri* as compared with *V. novaehollandiae*, on which some emphasis was placed in the earlier account, appears perhaps insufficiently pronounced to justify the significance there attached to it, and in Mr Singline's example the ratio eye in interorbital, 1.14, falls within the range (1-1.2) given by Munro for *V. novaehollandiae*. For the latter species gill rakers are reported as 4-5+12: for the 1964 material of Johnston's species the count was 3+12; however, in the 1969 individual the anterior arch bears only 4+9 gill rakers. The lateral line count is here 25 (*cf.* 27; and for *V. novaehollandiae*, 24-27).

Proportions as TLs.—Most of the proportions, expressed as millesimals of standard length, recorded for the earlier specimens (1964, Table V) are noted below for the present fish; omissions being those necessitated by the imperfect condition of most of the rays and of the spine of the second dorsal. The general close agreement between the 3 individuals is indicated by the values of the coefficient of variation cited (in parentheses) after the *TLs* entries. The mean value of *V* is 4.47, with just over half the items having a magnitude of less than 3.0, and only 3 items reaching double figures. Head 397 (*V* 2.2); snout 88 (19.0); eye 147 (3.2); interorbital 129 (6.4); length to middle of vent 571 (2.7); length to first dorsal origin 418 (4.8), termination 538 (1.3) (spine) or 568 (membrane); length to second dorsal origin 594 (2.0), termination 706 (1.8) (spine; no posterior membrane; length to anal origin 600 (1.9), termination 753 (0.3); length to pectoral origin 365 (2.4), length (total) of fin 265 (1.1), length of longest (5th-6th ray) 228 (2.5); length to pelvic origin 382 (3.5), length (total) of fin 324 (4.1), length of spine 162 (5.8); lengths of spines of first dorsal 29 (13.0), 112 (2.7), 229 (4.3), 176 (2.2), 144 (2.6), 94 (2.3), 35 (7.6); lengths of anal spines 47 (14.6), 144 (7.4); depth at anterior border of eye 147 (6.5), posterior border of eye 324 (4.0), opercular border 412 (3.1), vent 338 (2.2), termination of anal 206 (6.9); maximum depth (occurring at first dorsal origin) 397 (2.2); depth of caudal peduncle 147 (1.2).

Length pattern of spines of first dorsal.—In the 2 examples previously reported upon it was found that the lengths of the spines of the first dorsal follow, with significant fidelity, a simple pattern: first, for the anterior suite of spines (I-III), in which spine length increases caudad, the logarithm of length of spine is a linear function of the logarithm of serial number of spine; while, secondly, for the posterior suite of spines (IV-VII), in which spine length decreases caudad, it is the logarithm of the difference between length of longest spine (III) and length of spine considered that is a linear function of the logarithm of the spine's (total) serial number. These relations obtain also in Mr Singline's fish. With L=length of spine; n (whether as on-the-line symbol or as suffix) =serial number of spine, L_3 denoting length of longest spine (III), we have, for the anterior 3 spines, the general equation

$$\log L_n = k \log n + d \qquad (i)$$

and, for the posterior 4 spines, the general equation

$$\log(L_3 - L_n) = k \log n - d \qquad (ii)$$

For specimens (*a*), (*b*) of 1964 and the present specimen, in that order, we find for the anterior spines (lengths here, and throughout, in millimetres)

$$\log L_n = 1.507 \log n + 0.438 \qquad (iii)$$
$$\log L_n = 1.662 \log n + 0.420 \qquad (iv)$$
$$\log L_n = 1.876 \log n + 0.004 \qquad (v)$$

Values of t for (*iii*), (*iv*), (*v*) are 21.94*, 32.23*, 46.80*, respectively. For the same specimens the equations found for the posterior spines are

$$\log (L_3 - L_n) = 2.650 \log n - 1.189 \qquad (vi)$$
$$\log (L_3 - L_n) = 2.656 \log n - 1.124 \qquad (vii)$$
$$\log (L_3 - L_n) = 2.337 \log n - 1.589 \qquad (viii)$$

Values of t for (*vi*), (*vii*), (*viii*) are 6.38*, 35.33**, 40.12**, respectively.

For the holotype, total length 4 inches, Johnston reported only 6 spines in the first dorsal, giving their lengths as 7, 16, 15, 13, 8, 3 mm. In the 1964 individuals, of comparable size (*Lt* 86.9, 91.1), the 7 spines measure (*a*) 2.7, 8.1, 14.0, 11.5, 9.4, 6.7, 2.4; (*b*) 2.6, 8.6, 16.0, 13.0, 10.7, 6.9, 3.0. The possibility presents itself (1964: 102) that in Johnston's fish a spine, corresponding to our I, was missing or was overlooked. If the assumption is made that Johnston's I-VI correspond to II-VII of our material, equations (*i*), (*ii*) here become

$$\log L_n = 2.037 \log n + 0.232 \qquad (ix)$$
$$\log L_3 - L_n = 4.689 \log n - 2.805 \qquad (x)$$

For (*x*) $t=9.21$*. It will be noted (*a*) that in equation (*ix*) (2 spines only) the parameters are of the same order of magnitude as those in equations (*iii*), (*iv*), and also, in respect of the slope, as that in equation (*v*); (*b*) that equation (*x*) affords a satisfactory fit—these facts, together with the absolute magnitudes of the spine lengths as reported (of which latter the former of course are merely a formal codification) seem strongly to suggest that the 6 spines reported for the holotype are the homologues of II-VII in our material. However, no obvious reason is apparent for the noticeable difference in magnitude of the parameters of equation (*x*) and those of equations (*vi*), (*vii*), (*viii*).

Equation (*i*), $\log L_n=k \log n+d$ can also be written as

$$\log L_n=k \log n+\log b \qquad (xi)$$

or $$L_n=b \log n^k \qquad (xii)$$

Thus expressed, the relation is seen to be formally that of simple allometry or heterogony (Huxley, 1932). However, in place of the variables customarily involved in allometric growth studies—linear magnitude of an organism and of part of an organism (or of organ and of part of organ)—we here have linear magnitudes of a series of morphological entities and the natural numbers indicative of their sequence of insertion along the general anteroposterior axis of the organism: thus the equation, in this context, specifies a pattern of total growth (length) of a serial variate relative to its location. The ordinal numbers of the spines may represent a formulation in other terms of magnitude of anteroposterior extension of fish at points of spine-insertion. For equation (*ii*), $\log (L_3-L_n)=k \log n-d$, the graph of which presents a negative intercept on the $\log L_n$ axis, the general equation corresponding to the alternative form (*xii*) of (*i*), above, is

$$L_n=L_3-\frac{n^k}{b} \qquad (xiii)$$

In this equation in the 1964 paper the coefficient of n^k is printed as d (equivalent to present b), in error for its reciprocal.

Lengths of the spines of the first dorsal of the present specimen predicted by the regression equations (*v*), (*viii*)—for earlier examples, and, in part, the holotype see 1964 Table VI—are as follows (measured lengths in parentheses): 1.0 (1.0), 3.7 (3.8), 7.8 (7.9), 6.0 (6.0), 3.2 (3.2), 1.2 (1.2).

The best straight lines have been calculated with minimisation of the sum of the squares of the deviations of the logarithmic values. It has been found that the procedure, perhaps formally preferable, of fitting the line under the condition that the sum of the squares of the absolute residuals shall be a minimum yields equations that do not provide significantly better estimates of spine-length (1964, Table VI). In the estimation of significance the logarithmic values as plotted have been treated as raw data for the calculation of *t*.

Family SCORPIDAE

Only one member of the family, *Scorpis georgianus* Valenciennes, 1832, is credited to Tasmania in the Check-List (McCulloch, 1929: 237). A second species, *S. aequipinnis* Richardson, 1848 (type locality, King George's Sound, Western Australia; no other State noted in Check-List) has been added to the local list by the writer (1935: 67); the record based on 2 examples from near George Town, Dorset. A third species, *S. lineolatus* Kner, 1865, is here reported from Tasmania: the distribution given in the Check-List is Queensland, New South Wales, Lord Howe Island; the species does not appear in T. D. Scott's catalogue of South Australian fishes (1962).

The subjoined key to these three species leans heavily on McCulloch (1917). For *S. georgianus* McCulloch has D. x, 24-25, A. iii, 25-26, for *S. aequipinnis* D. ix-x, 25 (-27), A. iii, 25-26: counts of dorsal rays recorded by Scott (1962: 223) are 23-24, 27-28, and of anal rays 25-26, 25-26, respectively.

Genus **SCORPIS** Valenciennes, 1832

Scorpis lineolatus Kner, 1865

Scorpis lineolatus Kner, 1865, Reise Novara, Zool. 1, Fische, pt 1: 108, pl. V, fig. 3. Type locality, Sydney.

Scorpis richardsonii Steindachner, 1866, *Sitzb. Akad. Wiss. Wien*, liii: 437, pl. V, fig. 1. Type locality, Port Jackson.

Agenor modestus Castelnau, 1879, *Proc. Linn. Soc. N.S.W.*, iii, 4: 350, 371. Type locality, Sydney Market.

KEY TO SCORPIDAE RECORDED FROM TASMANIA

1	Second dorsal and anal strongly produced anteriorly. Body with darker cross bars. Maxilla reaching to middle of pupil. Body, in adults, deeper, $\geq\frac{1}{2}$ length to hypural joint	*S. georgianus*
	Second dorsal and anal not or only slightly produced anteriorly. Body without darker cross bars. Maxilla not reaching to middle of pupil. Body, in adults, shallower, $\leq\frac{1}{2}$ length to hypural joint	2
2	Second dorsal and anal slightly produced anteriorly. Scales smaller, >100 above lateral line between its origin and hypural joint. Maxilla reaching to below anterior border of pupil, its width = to its distance from eye. Number of anal rays ≤ number of dorsal rays. Scales between pectoral base and ventral spine ≥20	*S. aequipinnis*
	Second dorsal and anal not produced anteriorly. Scales larger, <100 (=90) above lateral line between its origin and hypural joint. Maxilla not reaching to below anterior of pupil, its width > (decidedly) than its distance from eye. Number of anal rays ≥ number of dorsal rays. Scales between pectoral base and ventral spine <20 (=12-14)	*S. lineolatus*

TABLE 4

Scorpis lineolatus Kner, 1865. Fin counts, and dimensions as thousandths of standard length (*TLs*), of 7 juveniles from Swimcart Beach, Cornwall, Tasmania, 5 May, 1968.

Count or Dimension	Specimen: standard length, mm							Mode or Mean
	(*a*) 68.1	(*b*) 73.0	(*c*) 75.9	(*d*) 78.1	(*e*) 79.9	(*f*) 100.0	(*g*) 104.1	
Dorsal	x, 26	x, 27	x, 27	x, 27	x, 27	x, 27	ix, 28	x, 27
Anal	iii, 28	iii, 27	iii, 27	iii, 27	iii, 27	iii, 27	iii, 27	iii, 27
Pectoral (left, right)	18, 18	18, 18	18,(17)	18, 18	18, 18	18, 18	18, 18	18
Caudal, main rays	20	18	20	20	19	17	18	20
Total length	1,357	1,344	1,324	1,314	1,331	1,315	1,352	1,333.9± 6.7
Length to end of middle caudal rays	1,198	1,241	1,212	1,206	1,176	1,153	1,159	1,192.1±11.0
Length to origin of first dorsal	380	360	391	370	399	364	361	360.7± 2.9
Length to termination of first dorsal (spine base)	587	562	569	570	610	583	567	578.3± 5.4
Length to origin of second dorsal	601	575	588	580	625	596	580	592.1± 6.0
Length to termination of second dorsal (ray base)	903	879	899	886	897	883	878	889.3± 3.6
Length to origin of anal	577	519	565	538	508	502	504	530.4±10.7
Length to termination of anal	915	903	908	895	885	902	874	897.4± 4.9
Length to origin of pectoral	294	289	277	269	250	230	264	267.6± 7.8
Length of pectoral	251	258	250	244	236	250	246	247.9± 3.5
Length to origin of ventral	323	288	343	335	293	311	300	313.3± 7.4
Length of ventral	156	147	145	139	163	159	156	152.1± 3.0
Length to middle of vent	543	488	527	506	463	460	447	490.6±12.7
Head	308	296	316	288	307	260	288	294.7± 6.5
Snout	58	69	73	65	73	60	67	66.4± 2.1
Eye	109	110	105	101	108	95	91	102.7± 2.6
Interorbital	73	80	79	70	86	74	72	77.6± 2.6
Maximum depth	514	575	527	525	537	550	558	540.9± 7.0
Depth at end of operculum	455	493	448	442	469	455	461	460.4± 5.9
Depth at vent	507	548	514	513	526	540	543	527.3± 5.8
Depth of caudal peduncle	104	123	105	105	114	97	114	108.9± 2.8
Length of 2nd dorsal ray	176	173	171	160	169	162	164	167.8± 2.1
Length of last dorsal ray	48	55	53	51	50	50	50	50.9± 2.2
Length of last dorsal spine	132	129	129	128	125	115	125	126.1± 1.9
Length of 2nd anal ray	185	178	184	186	181	169	168	178.7± 2.6
Length of last anal ray	44	55	53	51	51	40	37	47.1± 2.4
Length of last anal spine	97	110	128	128	131	110	103	115.3± 4.8
Length of longest (4th) pectoral ray	235	227	219	206	219	220	220	220.9± 3.1
Length of longest (1st) ventral ray	135	130	132	134	149	141	140	137.3± 2.3

Tasmanian record.—*Scorpis lineolatus* is here added to the Tasmanian list on a record of 7 juveniles, *Ls* 68.1-104.1, $\bar{x}$ 82.73±5.71, *Lt* 92.4-140.7; $\bar{x}$ 110.31±8.41, caught during the St Helens Surf Angling Club's Championship at Swimcart Beach, near St Helens, Cornwall on 5 May 1968. One other juvenile, taken during an earlier competition, has also been examined. McCulloch (1927: 64) observes that in New South Wales 'young specimens are very plentiful in inlets, while adults are more commonly captured along the coast'. The fish reaches a length of about 300. We have here another entry in the interesting list of species recorded from New South Wales and Tasmania, but not reported from Victoria or South Australia. The present examples are designated (*a*)-(*g*) in order of increasing *Ls*.

Fin counts.—One example, (*g*), has D. ix, 28 (fish with 9 spines have been reported also in *S. aequipinnis*), 5 have D. x, 27 (in (*e*), (*f*) last ray split to base), 1, (*a*), x, 26. All show A. iii, 27 (in (*b*), (*d*) last ray split to base) except smallest, which has A. iii, 28. Apart from one imperfect fin—right of (*c*)—all pectorals, on both sides, have 18 rays. Main caudal rays 17-20.

Dimensions and proportions.—A set of dimensions, expressed as *TLs*, is given in Table 4. These millesimals in general exhibit a satisfactorily low measure of variability, only 2 of the 29 items having a coefficient of variation in excess of 10 (length of last anal ray 13.7, length of last anal spine 10.9), *V* for the rest having a frequency distribution for classes 1-9 of 3, 3, 5, 6, 2, 2, 3, 2, 1; the mean value (all items) being 5.26±0.50.

Values of range /σ vary from 1.52 to 5.01, with $\bar{x}$ 2.96±0.11, no fewer than 18 entries lying within ±0.50 of 2.70, the mean value in the normal distribution with $n=7$.

Ranges and means of important diagnostic proportions are: head in *Ls* 3.2-3.8, 3.40±0.08; length to vent in *Ls* 1.8-2.2, 2.06±0.03; trunk in head 1.3-1.8, 1.51±0.07; eye in head 2.7-3.2, 2.88±0.05; snout in eye 1.4-1.9, 1.55±0.09; interorbital in eye 1.3-1.4, 1.32±0.06; first dorsal base in second dorsal base 1.3-1.5, 1.43±0.03; anal base in second dorsal base 1.1-1.4, 1.24±0.04; length of pectoral in head 1.2-1.3, 1.21±0.02; length of ventral in head 1.6-2.2, 1.94±0.06; maximum depth in *Ls* 1.7-2.0, 1.85±0.03; depth at vent in *Ls* 1.8-2.1, 1.92±0.03; 2nd dorsal ray in head 1.6-1.9, 1.75±0.03; 2nd anal ray in head 1.5-1.7, 1.62±0.03; last dorsal ray in 2nd dorsal ray 3.1-3.7, 3.31±0.07; last anal ray in 2nd anal ray 3.3-4.6, 3.87±0.04; longest (4th) pectoral ray in head 1.2-1.5, 1.33±0.03; longest (outermost) ventral ray in head 1.8-2.4, 2.15±0.06; last dorsal spine in head 2.2-2.5, 2.34±0.03; last anal spine in head 2.1-3.2, 2.56±0.13. For these proportions, values of *V* are tolerably low, exceeding 10 in only 2 instances (snout in eye 16.0, trunk in head 13.1), the distribution of the remaining 19 items being, for $V=1\text{-}9$, 1, 0, 3, 5, 3, 2, 3, 1, 1; $\bar{x}$ 6.02±0.55.

Within the sample a significant correlation of a recorded *TLs* value, other than for rays or spines, with *Ls* is afforded by eye diameter, with r −0.94, z 1.74, t 6.18**. However, all 8 *TLs* values for rays and spines given in table 4, except the last entry (longest ventral ray) exhibit a negative correlation with *Ls*, though this correlation is statistically significant in 3 cases only, namely, last dorsal spine (r −0.79, z 1.08, t 2.91*), 2nd anal ray (r −0.90, z 1.49, t 4.68**), last anal ray (r−0.77, z 1.01, t 2.68*).

Compared with the standard figure, reproduced in McCulloch (1927, pl. xxvi, fig. 227*a*) the juveniles exhibit relatively greater extensions in the anterior regions, with larger *TLs* values for head and for lengths to origins of dorsal, anal, and ventral fins; greater relative values are found also for eye, length of ventral, maximum depth, all perhaps expectable in juvenile material. McCulloch (1917: 179) has noted some proportions of a specimen 257 in length to end of middle caudal rays as follows: depth at ventrals 2.2 in *Ls*; head 3.7 in *Ls*; eye, 2nd dorsal ray, 2nd anal ray 3.7, 2.1, 2.9, respectively, in head: in each case the mean size of the region or organ cited as denominator is greater in our examples. In McCulloch's fish 2nd anal ray exceeds, in our example is shorter than, 2nd dorsal ray.

Other features.—Scale counts are compatible with those recorded by McCulloch (his values in parentheses): scales above lateral line between its origin and hypural joint *ca* 87-*ca* 94 (about ninety); between *base* of anterior dorsal rays and lateral line 14-16 (about fifteen); between base of pectoral and ventral spine 11-14 (about thirteen). Maxilla fails to reach level of pupil, falling short of it by 0.2-0.7 of interval between anterior borders of pupil and eye; its distal width 2.2-3.5 (McCulloch, much greater than) its distance from eye. Whole border of preoperculum and about lower half of preorbital border ctenoid. In all examples except (*a*) and (*c*) ventral extends to level of vent. Adpressed pectoral reaches to, or in smaller individuals just falls short of, level of origin of anal.

Family LABRIDAE

Labridae credited to Tasmania in the Check-List (in Coridae) are: (*i*) *Pictilabrus laticlavius* (Richardson), 1839 [genus *Pictilabrus* Gill, 1892]; (*ii*) *Pseudolabrus fucicola* (Richardson), 1840 [genus *Pseudolabrus* Bleeker, 1862]; (*iii*) *P. miles* (Bloch & Schneider), 1801; (*iv*) *P. celidotus* (Bloch & Schneider), 1801; (*v*) *P. tetricus* (Richardson), 1840; (*vi*) *P. cuvieri* (Castelnau), 1873. Of these no fewer than 3—(*i*), (*ii*), (*v*)—have Tasmania as type locality (all Port Arthur [Pembroke]); further, Tasmania provides type localities for 2 species synonymized by McCulloch with (*iii*), namely, *Labrus psittaculus* Richardson, 1840 (Port Arthur) and *Labrichthys mortoni* Johnston, 1885 (mouth of the Derwent River [Monmouth/Buckingham]), as well as for 1 species synonymized by McCulloch with (*iv*), namely, *Labrus botryocosmus* Richardson, 1846 (South Australia and Van Diemen's Land). Lord & Scott (1924) omit (*v*), and replace (*iii*) by a species synonymized by McCulloch with that form, namely, *Labrus psittaculus* Richardson, 1840 (appearing in *Pseudolabrus*), sinking in this Johnston's 1885 species. On p. 74 Lord & Scott credit (*i*) to Cuvier & Valenciennes, but correctly enter it in their list on p. 12.

Astrolabrus maculatus (Macleay), 1881 [genus *Austrolabrus* Steindachner, 1883] was added to our list in Part V (1942: 50), on the strength of an example secured in a trawl at the mouth of the Tamar River, Devon/Dorset, in December 1939. *Pseudolabrus parilis* (Richardson), 1850 is here for the first time reported from Tasmanian waters.

Genus **PSEUDOLABRUS** Bleeker, 1862

Pseudolabrus parilis (Richardson), 1850

Tautoga parila Richardson, 1850, *Proc. Zool. Soc. Lond.*: 70. Type locality, King George's Sound, Western Australia.

Labrichthys rubra Castelnau, 1875, *Res. Fish. Austr.* (*Vict. Offic. Rec. Philad. Exhib.*): 37. Type locality, Swan River, Western Australia.

Pseudolabrus parilis (Richardson). McCulloch, 1929, *Austr. Mus. Mem.* V, IV: 311.

Tasmanian record.—The species is added to the Tasmanian list on the basis of a specimen, *Ls* 112, *Lt* 138, collected (Rowley) at Low Head, Dorset, 16 July 1964 Queen Vict. Mus. Reg. No. 1969.5.30). Examples have been seen also in collections made (R. H. Green) on the reef at Green's Beach, Devon.

Remarks.—D. ix, 11. A. iii, 10. P. 12. V. i, 5. C. 17. 10 contributing to posterior border. L. lat. 25 (on left, 18 in upper segment, 2 connectives, 5 in lower segment; on right, 19+1+5). L. tr. 2+1+9.

Dorsal originating just in advance of level of opercular lobe, length to origin 3.56 in *Ls*, 1.17 its spinous base (spine-spine), which is 1.37 in soft base (ray-ray). Dorsal spines increasing behind 1st, the longest (last) 1.52 in longest (3rd) dorsal ray, which is equal to longest (3rd-4th) anal ray. Anal originating beneath 1st, terminating beneath penultimate, dorsal ray. Pectoral broadly rounded, its length subequal to head without snout, extending to level of 7th dorsal spine, not reaching anal origin [contrast figure reproduced in Scott (1962: 275)]. Ventral pointed, subequal in length to postorbital head, extending 0.59 of distance to anal. Head 3.5 in *Ls*. Eye equal to interorbital, 1.12 in snout, 4.57 in head. Greatest depth, occurring about at end of adpressed pectoral, just exceeding head, 1.69 depth of caudal peduncle, which is 2.79 eye. In each side of upper jaw a single series of about a dozen teeth, the anterior one a curved canine, the remainder decreasing backward from the 2nd, which is about half the 1st; internal to the bases of the first 4 teeth a row of 6-7 minute teeth, barely erupted, possibly representing a replacer series; well behind the main teeth, and noticeably external to their general line, a pair of closely set canines. In each half of lower jaw a single row of about a dozen teeth, decreasing in size backward. Scales large, extending forward mesially on dorsum, in 4 or 5 predorsal rows, to level of preopercular border, continuing laterally, by 2 or 3 large scales on each side, to reach upper hind border of eye; beginning adjacent to these large scales, and extending round lower posterior quadrant of eye, small scales, in 1 row above, in 2 or 3 rows below.

In general more or less horn coloured, tolerably uniform, with a number of small scattered, obscurely delimited dark splashes or spots. No dark lines radiating from eye [contrast Scott: 278]. Dorsal with a conspicuous dark area on first 2 interspaces between rays, a conspicuous spot on basal half of last interspace, some small obscure dark markings elsewhere. Anal darker along free margin. Caudal somewhat dusky distally. Pectoral and ventral pale brown, immaculate. Examples from Green's Beach, examined earlier, exhibited a ground colour predominantly greenish.

Family PLATYCEPHALIDAE

In the Check-List only a single species, entered as *Platycephalus bassensis* Cuvier & Valenciennes, 1829, is definitely credited to Tasmania, with this State as a queried locality for a second species, *P. fuscus* Cuvier & Valenciennes, 1829 [both are described in vol. IV of *Nat. Hist. Poiss.*, which is by Cuvier]. The first of these is now recognised as including, besides the typical form from the eastern States, a Western Australian subspecies, *P. b. westraliae* Whitley, 1938. The second species is now accepted as a Tasmanian fish (*cf.* Scott, 1962: 148). A third species, *P. laevigatus* Cuvier, 1829, not treated as Tasmanian by McCulloch (1929) or by Scott (1962), is included in the local list of Lord (1923), and appears in Lord & Scott's Tasmanian vertebrate synopsis (1924), unaccompanied by precise locality records. A note on the Tasmanian status of a fourth species, *Neoplatycephalus speculator* (Klunzinger), 1872, appears below.

Platycephalus bassensis, *P. fuscus* and *Neoplatycephalus speculator* have been nominated by Whitley (1938) as orthotypes of three genera, *Trudis*, *Planipora*, *Cacumen*, respectively: in his recent Australian list (1964) the first two of these are retained, the third is abandoned.

Lord & Scott also treat as a member of this family *Oplichthys haswelli* McCulloch, 1907, referred in the Check-List to Oplichthyidae: in both the original account (McCulloch, 1907: 351, pl. lxiv) and in Lord & Scott the generic name is rendered as *Hoplichthys*—the two spellings occurring in Cuvier (1829). Oplichthids are naked, and have a row of spinate bucklers on each side: platycephalids are scaled, and lack the bucklers.

KEY TO PLATYCEPHALIDAE RECORDED FROM TASMANIA

1	Jaws and palate with canines. First dorsal base $>\frac{1}{2}$ anal base	*Neoplatycephalus speculator*
	Jaws and palate without canines. First dorsal base $\leq\frac{1}{2}$ anal base	2
2	Anal origin in advance of second dorsal origin. Preopercular spines strong, the lower the longer	*Platycephalus bassensis bassensis*
	Anal origin behind second dorsal origin. Preopercular spines weak, subequal, or the upper the longer	3
3	First and second dorsals continuous or subcontinuous. Anal termination not, or barely, behind second dorsal termination. Upper surface of head without ridges. Interorbital < transverse diameter of eye. Ventral without produced rays, subequal to pectoral. Flank with closely set large rounded brown spots	*Platycephalus laevigatus*
	First and second dorsals not continuous (separated by about an eye diameter). Anal termination behind second dorsal termination (by 2-3 rays). Upper surface of head with ridges. Interorbital > transverse diameter of eye. Ventral with one or more rays produced, longer than pectoral. Flank with irregular dark markings	*Platycephalus fuscus*

Two South Australian species it would not be altogether surprising to find extending to our waters are *Thysanophrys cirronasus* (Richardson), 1848 and *Platycephalus haackei* Steindachner, 1844. The former agrees with *Neoplatycephalus*, and differs from other species in the key, in having first dorsal base $>\frac{1}{2}$ anal base: it differs from Klunzinger's species in having the teeth villiform, and in possessing a rostral tentacle. *P. haackei* would run down to the third couplet of the key: it can be separated from both species there by having head subequal to interval between origin of second dorsal and hypural joint, instead of subequal to dorsal base, and by having combined dorsal and anal rays about 23-24 (*cf. P. fuscus* modally 26, *C. laevigatus* modally 28).

Genus **NEOPLATYCEPHALUS** Castelnau, 1872

Neoplatycephalus speculator (Klunzinger), 1872

Platycephalus speculator Klunzinger, 1872, *Arch. Naturg.* xxxviii, 1: 28. Type locality, Hobson's Bay.

Tasmanian status.—This species does not occur in any of the local lists of Johnston (1883, 1891), Lord (1923), Lord & Scott (1924); nor, as a Tasmanian fish, in McCulloch (1929), Scott (1962). In a paper on fishes trawled in the Great Australian Bight, Munro & Kurth (1960: 19) state 'It is now known to extend along the coast off Victoria, Tasmania, South Australia and Western Australia'. A specimen obtained at one of three trawl stations in Bass Strait, east of the Hogan Group, occupied by the Japanese research vessel *Umitaka Maru* on 19 January 1968 has been noted in a systematic list of the fishes collected by that expedition in Tasmanian waters (Harrison & Scott, 1969: 9, 11).

Genus **PLATYCEPHALUS** Bloch, 1795

Platycephalus bassensis bassensis Cuvier, 1829

Platycephalus bassensis Cuvier, 1829, *Hist. Nat. Poiss.*, IV: 247. Type locality, Port Western, Victoria.

Platycephalus tasmanius Richardson, 1842, *Trans. Zool. Soc. Lond.*, iii: 96. Type locality, Port Arthur [Pembroke], Tasmania.

Platycephalus bassensis bassensis Cuvier & Valenciennes. Scott, 1962, Marine and Fresh Water Fishes of South Australia: 148, unnumbered fig. on p. 148.

Variation in fin counts.—A current conventional diagnosis (Scott, 1962: 148) gives D. vii-viii, 14: A. 14. A sample of 11 examples from Swimcart Beach, near St Helens, Cornwall (St Helens Surf Angling Club Championship, 4 May 1968) provides the following counts: D. vii, 13 (1 specimen; last ray split to base), vii, 14 (8; last ray split to base in 3), vii, 15 (1), viii, 14 (1): A. 13 (1), 14 (10).

The standard length of the sample was 289-448, $\bar{x}$ 361.1±13.1, σ 43.4±9.04, V 12.0±2.6.

References

Berg, L. S., 1940.—The Classification of Fishes both Recent and Fossil. *Trav. Inst. Zool. Acad. Sci. U.R.S.S.*, 5: 87-517, 90 figs (in Russian: not seen). Edition in Russian and English, 1947, Ann Arbor, Michigan, U.S.A.

Gunther, A., 1870.—*Catalogue of the Acanthopterygian Fishes in the Collection of the British Museum*, viii. London.

Harrison, A. J. & Scott, E. O. G., 1969.—A Systematic List of the Fishes Collected in Tasmanian Waters by the *Umitaka Maru* in January 1968. *Tasm. Fish. Res.*, 3, 1: 7-11.

Huxley, J. S., 1932.—*Problems of Relative Growth.* London.

Johnston, R. M., 1883.—General and Critical Observations on the Fishes of Tasmania with a Classified Catalogue of all known Species. *Pap. Proc. Roy. Soc. Tasm.*, 1882: 58-144.

————, 1891.—Further Observations upon the Fishes and Fishing Industries of Tasmania, together with a Revised List of Indigenous Species. *Pap. Proc. Roy. Soc. Tasm.*, 1890: 22-46.

Lord, C. E., 1923.—A List of the Fishes of Tasmania. *Pap. Proc. Roy. Soc. Tasm.*, 1922: 60-73.

———— & Scott, H. H., 1924.—*A Synopsis of the Vertebrate Animals of Tasmania.* Hobart.

McCulloch, A. R., 1907.—The Results of Deep-Sea Investigation in the Tasman Sea: ii. The Expedition of the 'Woy Woy': 1. Fishes and Crustaceans from Eight Hundred Fathoms. *Rec. Austr. Mus.*, 6, 5: 345-355, pl. lviii-lxv, text fig. 55.

————, 1911.—Report on the Fishes obtained by the F.I.S. 'Endeavour' on the Coasts of New South Wales, Victoria, South Australia and Tasmania. Part 1. *Zool. Res. Endeavour*, 1, 1: 1-87, pl. i-xvi.

————, 1917.—Studies in Australian Fishes. No. 4. *Rec. Austr. Mus.*, 11, 7: 163-188, pl. 29-31, text figs 1-2.

————, 1926.—Report on some Fishes obtained by the F.I.S. 'Endeavour' on the Coasts of Queensland, New South Wales, Victoria, Tasmania, South and South-Western Australia. Part V. *Biol. Res. Endeavour*, 5, 4: 157-216, pl. xliii-lvi, figs 1-4.

————, 1927.—*The Fishes and Fish-Like Animals of New South Wales*: 2nd ed., with additions by G. P. Whitley. Sydney.

————, 1929.—A Check-List of the Fishes Recorded from Australia. *Austr. Mus. Mem.*, V, i-iii (iv, Index, 1930).

Munro, I. S. R., 1957.—Handbook of Australian Fishes; serially in *Fisheries Newsletter* (subsequently *Australian Fisheries Newsletter*, now *Australian Fisheries*), 16, 8 and 9 [Macruridae]. Canberra.

————, 1958.—Handbook of Australian Fishes. *Fish. Newsl.* [see 1957 entry], 17, 2-5 [Syngnathidae].

————, 1960.—Handbook of Australian Fishes. *Fish. Newsl.* [see 1957 entry], 19, 8-12 [Apogonidae].

———— & Kurth, D. E., 1960.—Trawl Fishes of the Bight. *Fish. Newsl.* [see previous entry], 19, 7: 16-21, figs 1-17.

Ogilby, J. D., 1897.—Some Tasmanian Fishes. *Pap. Proc. Roy. Soc. Tasm.*, 1896: 69-85.

Phillipps, W. J., 1927.—Notes on New Zealand Fishes. *Trans. Proc. N.Z. Inst.*, 58: 125-135, pl. 3-8.

Scott, E. O. G., 1935.—Observations on Some Tasmanian Fishes: Part III. *Pap. Proc. Roy. Soc. Tasm.*, 1934: 63-73, pl. V.

————, 1939.—Observations on Some Tasmanian Fishes: Part IV. *Pap. Proc. Roy. Soc. Tasm.*, 1938: 139-159, text figs 1-2.

————, 1942.—*Syngnathus tuckeri sp. nov*: A New Tasmanian Pipefish. *Rec. Queen Vict. Mus.*, 1, 1: 17-20, pl. V.

————, 1953.—Observations on Some Tasmanian Fishes: Part VI. *Pap. Proc. Roy. Soc. Tasm.*, 1952: 141-164, figs 1-4.

————, 1955.—Observations on Some Tasmanian Fishes: Part VII. *Pap. Proc. Roy. Soc. Tasm.*, 1954, 89: 131-166, pl. 1.

————, 1961.—Observations on Some Tasmanian Fishes: Part X. *Pap. Proc. Roy. Soc. Tasm.*, 1960, 95: 49-65, figs 1-3.

————, 1967.—Observations on Some Tasmanian Fishes: Part XV. *Pap. Proc. Roy. Soc. Tasm.*, 1966, 101: 189-220, figs 1-3.

SCOTT, E. O. G., 1968.—First Tasmanian Record of the Long-snouted Pipefish, *Syngnathus poecilolaemus* Peters. *Tasm. Fish. Res.*, 2, 2: 4-7.

SCOTT, T. D., 1962.—*The Marine and Fresh Water Fishes of South Australia.* Adelaide.

WAITE, E. R., 1911.—Scientific Results of the New Zealand Government Trawling Expedition, 1907. Pisces, Part II. *Rec. Canterb. Mus.*, 1, 3: 157-258, pl. XXIV-LVII, figs 1-3.

———— & HALE, H. M., 1921.—Review of the Lophobranchiate Fishes of South Australia. *Rec. S. Austr. Mus.*, 1, 4: 293-324, figs 39-56.

WHITLEY, G. P., 1931.—New Names for Australian Fishes. *Austr. Zool.*, 6, 4: 310-334, pl. xxxv-xxxvii, and text fig.

————, 1938.—Studies in Ichthyology. No. 11. *Rec. Austr. Mus.*, XX, 3: 195-199, pl. XXI, and fig 1.

————, 1964.—A Survey of Australian Ichthyology: Presidential Address. *Proc. Linn. Soc. N.S.W.*, LXXXIX, 1: 11-127.

————, 1968.—A Check-list of the Fishes Recorded from the New Zealand Region. *Austr. Zool.*, XV, 1: 1-102.

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THE TRIALS OF W. L. NEALE

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ABSTRACT

W. L. Neale, the Chief Inspector of the Education Department of South Australia, was invited to accept appointment as Director of Education in Tasmania in 1905. His attempts to centralise control of the Department antagonised the local Boards of Advice and his curricular innovations confused the many incompetent teachers, whom he rebuked and criticised publicly. The opposition of these two groups to Neale was so bitter that three Royal Commissions were held to investigate allegations made against him. The few competent teachers supported Neale, but his own lack of tact alienated public opinion and Parliament accepted the recommendation of the third Commission to terminate his services.

His ability was outstanding and his dismissal a sad setback to education in Tasmania.

THE APPOINTMENT OF NEALE AS DIRECTOR OF EDUCATION

In 1904 Tasmania's financial position was critical. Every available penny had to be used to the best advantage. Retrenchment and economy were the aims of Parliament and both the efficiency and the expenditure of all government departments were examined carefully to ascertain whether the expenditure was justified by the value of their activities.

The Premier, W. B. Propsting, sought permission from the South Australian Premier for W. L. Neale, the Chief Inspector of the South Australian Education Department, to visit Tasmania and to report on all aspects of the work of the Education Department[1]. Neale was regarded as one of the ablest administrators in the Department, with a high reputation throughout Australia and New Zealand.

Neale was given leave from his position in South Australia. He first visited Victoria and New South Wales to observe the work of their Departments of Education. Then he spent two months in Tasmania. He visited thirty-seven schools and submitted a report[2] of 50,000 words in which he examined every aspect of education in the State.

Neale was a visionary, a crusader, and an idealist, who had accepted many aspects of the 'new education' which Pestalozzi, Herbart, Froebel and Dewey[3] had advocated. He was critical, impatient and intolerant, and had little sympathy for those who were unwilling to keep themselves abreast of modern developments. It is not surprising that his report was blunt and scathing. He asserted:—

> 'Hardly an echo of the educational renaissance of the last quarter of a century seems to have reached Tasmania. The method is an uninteresting drill; and the form of the method . . . is condemned by all authorities. Even the Model School is an exponent of methods that lead to ineffectiveness'[4].

Neale was not solely critical; he also propounded an ideal system of education, set out in detail the improvements that were necessary in order to achieve such perfection, and specified the means of implementing them. He concluded that education in Tasmania was 'very far from being even moderately efficient'[5].

In July 1904, J. W. Evans succeeded Propsting as Premier[6]. When Neale was invited to Tasmania Propsting had assured the South Australian Premier that there was no intention of asking Neale to remain permanently, but Evans offered him appointment as Director. The previous Director, Joseph Masters, was appointed Secretary for Education and therefore in theory became Neale's second-in-command[7].

The announcement of Neale's appointment was accepted with little opposition in the House of Assembly. Few members were interested in education but all were interested in efficiency and economy, and Evans convinced his colleagues that Neale would bring both qualities to the Department.

The Legislative Council applauded even more loudly than the Assembly the aim of economy, but members objected strongly to the decision that it should be Neale who was to effect the economies. Many of the Councillors were chairmen of local Boards of Advice[8] and had been incensed by Neale's criticism of the Boards, and his recommendation that the central authority of the Department should be strengthened and the powers of the Boards decreased. The Legislative Councillors feared the loss of their prestige and patronage, feared an increase in government expenditure that would increase the land taxes, and resented a stranger criticising the results of the administration of a State department.

Their resentment was so strong[9] that they appointed a Select Committee of the Council to

investigate and report on the Report which Neale had submitted, but Select Committees were able to meet only while Parliament was in session, and the adjournment of Parliament meant that Neale commenced duties before the Committee could meet.

The criticism of Neale's appointment by the Legislative Council was so severe that Evans was not willing to risk further trouble by allowing Neale to arrive in the middle of January 1905, which he had requested, instead of the beginning of the month. In addition, Neale's removal expenses which had been promised to him by the Premier were at first refused by the Council, and only after two further submissions by the Premier did Council authorise payment of half the cost of removal.

In South Australia, where Neale and his work were well known, there were no reservations about the wisdom of his appointment. The Assistant Inspector-General of the Education Department told a public meeting of farewell that 'Tasmania was gaining an educational statesman', and that South Australia 'was losing an inspector who . . . had a vision of the highest levels of education'. The Senior Inspector stated that Neale 'had done excellent work in every department' and described him as 'one of the greatest and most statesmanlike inspectors in Australia'[10].

In Tasmania, however, the outlook was not favourable. Neale inherited a teaching service which lacked ability, and which had been antagonised by the stinging public condemnation which his report had administered six months before. His report had paid little heed to Tasmanian customs or to the difficulties under which the teachers worked, and this caused them to believe that he was unaware of the difficulties and not interested in their welfare. The resentment of the teachers was accentuated by the realisation that Neale was to remain in Tasmania to put into effect the improvements and economies he had recommended. They found their greatest support came from the Legislative Council.

'The forces of blind conservatism and vested interest are arrayed against him.'[11]. Encouraged 'by legislators and less responsible persons, the school teachers [in Hobart] have practically revolted'[12]. It was the 'Legislative Council, with their usual penchant for mischief', from whom 'the incompetent teacher [was seeking] sympathy and political influence'[13]. The unusual alliance of poor, incompetent teachers and wealthy landowners was joined by the infant Labour Party which, supporting the miners and small farmers in the backblocks, resented criticism of the poor teachers in these areas.

This combination of forces was particularly strong in rural areas, where education was weakest, reform was most necessary and conservatism was strongest. It was obvious that Neale's task would be difficult.

Neale's Innovations and Improvements

Neale assumed office in January 1905. He gave first attention to innovations and improvements that were clearly necessary, not controversial and unlikely to increase the State's expenditure. His early decisions aroused almost no criticism and in September 1905, the House of Assembly accepted the Education Department estimates for the following year without reservation. Nine members from both sides of the House praised his work, with none dissenting, and the Premier, speaking as Minister for Education, expressed the desire to 'place on record [his] high appreciation of Mr Neale's ability'[14].

One of Neale's first acts was to establish a monthly journal, *The Educational Record*, which he used to convey his instructions to teachers. In this way he not only asserted the authority of a central administration but also advised his teachers of new ideas and encouraged them to greater efforts.

In particular, he used *The Educational Record* to introduce to Tasmania many aspects of the 'new education' which were becoming accepted in other countries and other States[15]. He retained some of the formal drill of his predecessors but added music, drawing, nature study and physical culture to enliven the studies of the children. 'It is not sufficient that children should be well behaved. They should also be mentally alert, anxious to work, and constantly making effort'[16]. He also advocated craft work—simple plasticine modelling for the very young children and elementary woodwork for older boys. He urged his teachers to encourage the children to brighten the classrooms by bringing flowers to school, or by providing plants in pots. He also urged his teachers to establish drum and fife bands, to organise concerts and part-singing, and displays of art work and classroom decorations.

In order to introduce these new topics and new methods Neale sought opportunities to provide experience and training for teachers in the Department.

Neale sent six of his teachers to the Teachers College in Melbourne to acquaint them with modern teaching methods and philosophy, and sent a woodwork and cookery teacher to work in such schools in Victoria. On their return he persuaded the Government to convert an old fives court at the Army Barracks into a woodwork room and classes of twenty boys from Hobart and from nearby areas served by a railway spent half a day there each week. In this way 200 boys received regular instruction. He also had a room in the Central School in Hobart equipped as a cookery classroom, and 200 girls received instruction each week.

He submitted plans, provided by the Victorian Education Department, for the construction of woodwork and cookery 'schools'[17] in Launceston, hoping to have them ready when his teachers returned, but lack of finance prevented their construction.

In Hobart he introduced schemes for the education of deaf, dumb and blind children who had previously been neglected.

He sent one of his teachers to Froebel House Kindergarten Training College in Sydney to learn the elements of teaching very young children, for whom there was no provision in Tasmania.

Neale persuaded the Chief Health Officer of the Department of Public Health, Dr J. S. C. Elkington, to join him in requesting provision for medical examination of school children[18]. Later in the year Neale arranged with C. B. Peterson[19] to prepare detailed instructions for physical training courses[20] for publication in *The Educational Record* in order that teachers in all parts of Tasmania could benefit.

In 1906 Neale sought the appointment of a Schools Medical Officer under the control of the Education Department (despite the protests of the Department of Public Health, which believed that the officer should be responsible to that Department), and in 1907 Dr Gertrude Halley of Melbourne was appointed. In the following year two part-time officers were appointed—one in Hobart and one in Launceston[21].

Neale also used *The Educational Record* to advise the teachers that principles of hygiene were an essential aspect of education. They were instructed to open windows to allow proper ventilation (not only to introduce fresh air but also to disperse offensive body odours) and to instruct children in the need for regular bathing and washing[22].

Elkington and Neale campaigned vigorously and in 1908 more than 11,000 children were medically inspected. Elkington then reported to Parliament that 36% of them were unhealthy to such an extent that their educational progress was being hindered[23].

Neale sought to gain the interest of all citizens, especially parents, in the work that was being carried out in the schools and he arranged for an exhibition to be held in Launceston at the end of 1907. Not only the children resident in Launceston but more than 2,000 children from all parts of the State gave displays of their work, attracting very favourable publicity. Nevertheless, public unconcern was difficult to overcome and Neale sadly reported to his Minister that 'the parents as a whole are indifferent about education.'[24].

From 1904 to 1909 the average daily attendance in the State schools increased by more than 21%, even though the State's population increased by only 4.3%, but it was the effort of Neale's truant officers rather than any change of attitude by the parents that caused such an improvement.

Another significant factor in increasing attendance was Neale's insistence that the teachers were responsible for maintaining a satisfactory standard of enrolment. Neale warned his teachers that it was the Department's policy 'to pay according to success in teaching, success in managing subordinate teachers and success in attracting a good attendance'[25]. This policy caused considerable friction in many unforeseen ways. In 1907 the Teachers Union expressed strong opposition to the publication of a report by the Deparment of Public Health condemning the condition of many school buildings. The Union, worried that parents would be discouraged from sending their children to these schools, and would instead send them to one of the non-State schools, did not deny that the report was justified, but contended that it was 'naturally against our interests'[26] that the true situation should be made known.

On several occasions Neale sought to persuade Parliament to abolish fees. At first he was unsuccessful, but in 1908 he eventually achieved his goal[27], and thus removed one great obstacle that had prevented parents from seeking an education for their children.

Neale established a Training College in 1906, in which prospective teachers were able to continue their education beyond Grade VI. He arranged that suitable candidates at the age of about 14 were appointed monitors in schools for six months. After this probationary period they studied at the College for two years, were then appointed to the staff of a school for two more years, and then returned to the College for another year's study[28]. A few very capable students were permitted to remain at the College for an extra year, and in this time they studied some subjects at the University.

For the first five years the places in the fifth or senior year were made available to teachers already in the service of the Department, in an effort to lift teaching standards immediately, and to avoid the need that would otherwise exist to wait five years for the first benefits of the College to be transmitted to the schools.

J. A. Johnson, M.A., of New Zealand, was appointed Principal of the College. Johnson's staff consisted of two female assistants, with special teachers giving instruction in subjects such as woodwork, cookery, drill, etc. In the first year there were forty-four students. The work was at first carried out in the Technical College and then for four years in the buildings of the University until the Training College was built and ready for occupation at the beginning of 1911[29].

Neale at first sought to buy an area of the public Domain on which to erect the College, but the trustees, while expressing 'sympathy with you in your endeavour', felt that they could not allow any 'alineation' [*sic*] of the Domain. Neale then persuaded the University to sell him one acre of its site for £1,500, and found such an amount by using loan money voted for the erection of schools[30].

By 1910 the enrolment had grown to seventy-one, and forty students had qualified for matriculation at the University of Tasmania. Ten of these students had completed the first year of the B.A. course of the University. Without the lectures given at the College these teachers would almost certainly have ended their studies after completing their primary education.

Neale persuaded the Government to pass the Scholarship Act[31] as a necessary corollary to the establishment of the Training College. It provided financial assistance[32] for children who had completed their primary studies to enable them to undertake secondary education, either at a non-State school or at the Training College.

Neale also established a Practising School, where the Training College students could observe the best teachers of the Education Department and where these teachers could supervise practical training by the students. At first the existing school at Battery Point was used, mainly because of the teaching skill of G. V. Brooks, a young South Australian whom Neale had appointed First

Assistant at Battery Point. Two years later the new Trinity Hill School, known at Elizabeth Street School for many years, was used for training purposes, with Brooks as head teacher responsible for organising and supervising the teaching of the children and the training of the student-teachers.

In 1908 the East Launceston School became a Practising School for men and women older than 18 years who wished to become teachers. They were posted to the school for not more than six months and during this time were instructed and supervised by the head teacher before being accepted for permanent employment.

Neale also played a significant, though perhaps unwitting, role in strengthening the best of the non-State schools in Tasmania. He was not directly concerned with the welfare of these schools, but he was concerned with the welfare of the children who attended them, and with the welfare of children who were enrolled in them, but did not attend[33]. He therefore proposed that Parliament should set up a Registration Board, which would examine applications for registration by the proprietors of non-State schools. In 1906 Parliament created a Registration Board[34], with four representatives of the non-State schools, two of the Education Department, one of the University and one of the State-assisted technical schools.

Non-State schools were now forced to comply with minimum standards concerning accommodation and hygiene, and their teachers with standards of proficiency which, although extremely low, forced many practitioners to seek other avenues of remuneration. Neale was encouraged in his efforts by the principals of the better non-State schools. The Rev. C. G. Wilkinson, one of the co-principals of Launceston Church Grammar School and probably the most respected educator in Tasmania at the time, wrote to Neale of 'the great value and pressing need' of the proposed legislation[35]. The Act was supported by all except the unqualified proprietors whose livelihood was endangered.

The Registration Act forced many 'schools' to close because they could not meet the minimum standard that was prescribed, and forced many of their scholars into either the State schools or those non-State schools that survived. Thus the surviving non-State schools gained more pupils and, free of the handicap of ill-reputation that some of the proprietorial schools had created, gained also in public esteem.

Neale introduced a scheme for the bulk buying of text-books at a much lower cost than previously and he was unchallenged when he commented on several occasions that he had saved the State more by this single scheme than he had received in salary in the whole period of his appointment.

In the four years from Neale's appointment to the end of 1908 twenty-seven new schools were built but previous neglect had made the shortage of suitable buildings so acute that this was only a very small proportion of the number required. Even in Hobart, generally considered to be treated very favourably, there was an average daily attendance of 1,599 children in 1908 in four schools, which had been built to accommodate a maximum of 1,275 children. In rural areas the situation was worse.

Neale persuaded the Government to pass the Public Service Super-Annuation Fund Act 1905[36], whereby teachers and other government employees earning more than £50 per year could, if they wished, set aside 8% of their salary towards an annuity when they retired[37]. The Government did not contribute to the fund and the contributions were so hedged by regulations that many teachers did not join, but sufficient were interested to allow the scheme to be established.

Neale constantly advocated a wider provision of education by the State but Parliament's reluctance to increase expenditure frustrated all his efforts to do so. The erection of a kindergarten at Battery Point was approved in 1906 but the Public Works Department had insufficient funds to start the building, and it was not until 1911 that the room was erected. Neale urged the establishment of 'continuation schools' in which Grade VII classes would provide instruction beyond primary level for those children who required it. He frequently advocated agricultural education in rural areas and vocational education in the towns. Evans accepted Neale's proposals but made little effort to persuade Parliament to endorse them.

In July 1906, Evans asked Propsting to resume office as Minister for Education. There was growing resentment of Neale by the teachers and criticism of him in Parliament and Evans, affable and easy-going, with no knowledge of education and little interest in the Department, was glad to leave the troubles to Propsting and Neale[38].

The Opposition of the Teachers

Neale's innovations were welcomed by a few teachers but criticised by many as fads that had no relevance to the preparation of children for their future employment. In addition, Neale's brusque tactless manner offended and alienated many who would otherwise have supported him. However, it was a far more personal matter—salaries—which created an unbridgeable chasm between Neale and his teachers.

Neale had drawn up a scheme for the examination of teachers, based mainly on the ability of their pupils. This examination, which was designed to ensure that teachers who deserved promotion gained their due reward as well as to prevent the incompetent from progressing, was often conducted by Neale himself. In addition, the regulations concerning salaries were interpreted by Neale in a manner that appeared to show partiality towards a few at the expense of the majority. Some regulations related the teacher's salary to his ability and qualifications and others to the number of children enrolled in the school. Thus it was possible to justify, by quoting certain regulations, the reduction of a teacher's salary if his incompetence led him to be transferred to a smaller school, but it was also possible, by reference to other regulations, to claim that such an alteration was illegal.

> 'There are many very serious problems for the administration of the Department to solve before the state can be prevented from incurring ruinous expenditure for salaries, and before the extraordinary anomalies in salaries can be removed',

Neale had warned in 1904.

> 'Every day the solution of those questions is postponed the greater will be the difficulties, the stronger the opposition and the bitterer the heart-burning'[39].

The solution of Evans and Propsting was to 'suspend' the regulations in 1905[40]. However, the 'suspension' was never referred to Parliament or advised to the teachers. Propsting explained in 1909 that this was because the regulations had not really been suspended. It was simply, he said that 'they had not been strictly adhered to.'[41]. After the regulations were suspended Neale acted (and was forced to act) as he wished. The teachers, unaware that the regulations were no longer effective, were confused and suspicious and Neale's apparently preferential treatment of some teachers added to their distress.

In September 1905, the Premier's Budget Speech contained a brief reference to the need for the introduction of 'a few trained teachers for the lower grades'. Neale had advised the Teachers Union of his intention to invite eight South Australian teachers to accept positions in the Department and although the Union expressed regret that 'their own young teachers would be beaten in the competition for promotion' they eventually expressed themselves as 'fully satisfied'[42].

The Union accepted Neale's proposal for two reasons. One was that no qualified Tasmanian teachers were willing to apply for certain vacancies. Some vacancies were in rural districts, away from the amenities of the cities. Others offered bright prospects for future advancement but, because of the tangled salaries regulations, required acceptance of a lower initial salary than the teachers were already receiving. The other reason was simply that Neale advised the Union that only eight teachers would be recruited, and thus the 'competition for promotion' was unlikely to be strong.

During 1905 Neale had taken pains to keep the Teachers Union[43] informed of his plans and the Conference of the Union in November 1905, was not critical of his actions in any sphere of his work. It was generally agreed that Neale was 'gaining the confidence of the teachers and establishing that esprit de corps which is essential to success'[44]. However, the Union's attitude changed drastically when Neale, between January 1906, and May 1907, appointed twenty-six South Australians[45] and appeared to give them higher salaries than Tasmanian teachers with similar responsibilities.

Seven of the South Australians were appointed head teachers, but only two of them to large schools and one of these two was offered his position only when it was found that no local teachers had applied for the position. Eight were appointed to the newly-created position of First Assistant and eleven as assistants.

There is no doubt that the South Australians were good teachers. A. L. Brockett[46] praised their teaching skill, their 'spirit of discipline and capacity for hard work, and willingness to assist those who have less advantages than themselves'[47]. He stated in his 1906 report that two of the South Australians had been appointed head teachers and added:

> 'One has produced work of a quality I have not seen before in the State schools in Tasmania[48] . . . and the other has made his the third school in the State in numbers'[49],

when his excellent teaching increased the attendance from 270 to more than 500.

Nearly all the competent and qualified teachers, with nothing to fear from the competition of the 'imports', welcomed their arrival as a means of improving Tasmania's educational standards. The incompetent and unqualified teachers, with their future promotion obviously restricted and mindful of Neale's scathing criticism of their ability in his Report, began to fear that their employment, or at least their salary, was threatened. The Executive of the Teachers Union met in Launceston on 2 April 1907, and resolved:

> 'The teachers of Tasmania . . . most respectfully but most emphatically protest against the appointment of teachers from the other States to the charge of important schools seeing that there are Tasmanian teachers who . . . are entitled to such positions'[50].

Union officers advised Neale that teachers would never have accepted a position with a starting salary of £10 or £20 per year if they had been aware that 'the plums of the service would have been put out of their reach'[51].

Neale himself caused his relationship with his teachers to deteriorate by the manner in which he addressed them. He spoke or wrote to them without any apparent consideration for their feelings, and without due regard for the fact that the vague generalities, lax administration and almost complete absence of guidance and direction by his three predecessors had accustomed the teachers to believe that the control of each school was the responsibility of the teacher, not the Director. The teachers were supported in this view by the Boards of Advice which had assumed responsibilities far beyond those laid down in the 1885 Act. Thus any attempt by the Director to impose active direction on his schools was likely to confuse or offend the teachers and Boards, and any lack of tact would accentuate their discontent.

It was the sudden change from the tolerance of low standards and neglect of regulations by the previous Director to a rigid, intolerant insistence by Neale that the letter of the law must be obeyed, that upset his teachers and the Boards of Advice. Neale ignored past circumstances and insisted on immediate obedience to inflexible instructions and he imposed fines, which he euphemistically termed penalties[52], on teachers who broke the regulations.

It is not surprising that Neale often felt compelled to introduce inflexible regulations and to impose strong direction that allowed no error. Most of his teachers were incompetent[53], and many regarded teaching merely as a temporary vocation[54]. On the other hand it is no less surprising that teachers were offended by Neale's manner. When the teacher of the School at Mt Nicholas advised the Director that there was 'danger of total collapse' of the school because of earth

movement caused by mining activity, the Director replied that the Department accepted no responsibility for this inconvenient state of affairs. Neale advised the teacher to 'apply to the owners of the building immediately. If not safe, the school must be closed and you transferred'. Risking such a fate the teacher begged 'to again draw your attention to the necessity of something being done', and this time was advised that such matters as the total collapse of the school were not his responsibility. 'It is not [your] business to interfere or to express official opinions unless requested by superior officers'[55].

Neale's manner also offended the public and the Boards of Advice. In March 1907, an article appeared in the Burnie *Advocate*, alleging that country schools were overcrowded and understaffed, and that they suffered these disadvantages to a far greater extent than city schools[56]. Neale threatened legal action against the newspaper unless it revealed the name of the author of the article, not because the facts were incorrect but because he believed that he was being unfairly accused of bias against country children. Subsequently he threatened legal action against the author. The only way 'to stop the malicious misrepresentation by anonymous writers', Neale claimed, 'is to make an example of one or two of them'[57].

Neale strongly castigated several Boards for neglecting to enforce the Act concerning school attendance[58]. The Department paid the secretary of each Board for his duties, which were supposed to include 'prompt and regular enquiry into cases of non attendance . . .' Neale reported that there were 'only two or three who feel any responsibility about this matter or consider it their duty . . . The experiment of entirely entrusting to local authorities the enforcement of school attendance has hopelessly failed'[59].

Neale had refused requests from several Boards that the schools in their district should be closed at the time of the local harvest[60] for longer than the law permitted. With complete honesty he advised the Boards of the extent to which they could excuse children from regular attendance, but just as candidly and with considerable lack of tact reminded them that they could not exceed the prescribed limit[61].

The Support of the Teachers Union by Parliament

By the middle of 1907 the Boards of Advice were beginning to voice their criticism of Neale through Parliament. One Legislative Councillor spoke of Neale's 'brutality' to young women; another described the 'terror' of a teacher when he received a letter from Neale. Several confirmed the reports of serious discontent among the teachers.

Public opinion, influenced by the criticism of Neale by the teachers, the Boards and the parliamentarians, swung against Neale. It was alleged that he regarded teachers as 'mere puppets at the end of a string, to be manipulated by one of those little tin gods who are . . . dressed in a little brief authority'[62], and was advised that 'our own people should make quite as good teachers as those imported, especially from a little State like South Australia'. Emotions were so strong that facts were ignored. One correspondent to the *Mercury* alleged that thirty-four head teachers had resigned in the first thirty months of Neale's term of office because of his ill deeds, whereas in fact only five had resigned in this time and two of them because of pregnancy, which was presumably not the fault of Neale! Several correspondents alleged that there was an increasing number of retirements from the Department but in fact the total had fallen from 86 in 1905 to 74 in 1906, 49 in 1907 and 31 in the first ten months of 1908.

Some Tasmanians even began to see sinister motives in the most innocent acts. Because the food prepared by the cooking classes which had been established in Hobart was sold to the public at a cost of 6d. per meal Neale was accused of seeking to drive Hobart caterers out of business. 'Why are all these Adelaide fads thrust upon us?' asked a correspondent[63].

Most Tasmanians were not interested in education but Neale's opponents represented a considerable proportion of the remainder. They included many parents, whose income had been affected when Neale's truant inspectors prevented their children from accepting employment. They included the lazy and incompetent teachers whose ambition and energy were jeopardised by the importation of the South Australians. They included members of the Boards of Advice whose status and self-esteem had been decreased. They included also the patriots who felt that Tasmanians were quite competent to control their own affairs.

A minority defended Neale and referred both to the improvements he had wrought and the cause of the criticism. 'The whole of the trouble is . . . a wresting from (the Boards of Advice) of a power they once wielded not at all wisely nor well and their chagrin at losing a little tin throne is great. Not one district having an imported teacher will exchange for the old condition of things'[64]. 'The Tasmanians do not want to work [but] object to being left behind'[65]. A member of the House of Assembly alleged in debate that most complaints 'originated from dissatisfied teachers . . . who were unsuitable' and the Premier interjected to support the comment.

Evans and Propsting expressed admiration for Neale but neither gave him the protection he needed. Neither accepted the principle of ministerial responsibility for the activities of the Education Department. Neither contradicted the opinion that Neale was acting arbitrarily and contrary to regulations approved by Parliament when in fact the regulations had been 'suspended'. Neither confirmed that the Boards of Advice had been exceeding their authority and that Neale's advice, although regrettably blunt, was legally correct.

It was the lack of political support by Evans and Propsting that allowed discontent to grow, until Parliament felt compelled to appoint a Royal Commission to investigate the allegations. E. D. Dobbie, the Solicitor-General, was appointed chairman. Ernest Whitfield, a Launceston magistrate, and F. M. Young, of Hobart, were the other members.

There was considerable criticism that the Solicitor-General and a magistrate, both involved in activities under the authority of the Attorney-General's Department, should have been asked to report on the activities of the Education Department, as the Attorney-General, their superior officer, was also the Minister for Education. To ensure that justice could be seen to be done, William Hamilton, Assistant Chief Inspector of the Victorian Education Department, was added to the Commission as an expert judge who was not likely to be influenced by local feelings. The request of the teachers to be allowed to appoint a commissioner was refused but they were permitted to be represented by J. R. Rule, and Rule was permitted to have with him a teacher in the Department, D. M. Davis, to advise him.

The Commission first sat on 13 August 1907, without Hamilton, who was unable to arrive in Tasmania until 24 August, and heard evidence in camera on matters concerning administration. On 24 August in Launceston Rule introduced the first of seventy-six witnesses who wished to give evidence of unfair treatment of them by Neale. Neale had taken with him to Launceston more than 8 cwt of documents to illustrate his defence and he had no difficulty in convincing the Commission that the complaints were trivial and unjustified[66].

After several days Dobbie, in considerable indignation, asked Rule to refrain from wasting the Commission's time with trivial matters. Rule alleged that only by hearing all the complaints could the Commission judge the widespread nature of the discontent. When the Chairman persisted with his request that Rule should present only significant cases Rule advised his witnesses neither to withdraw their complaints nor to elaborate on them, withdrew his representation of the teachers, and requested Herbert Nicholls, M.H.A., to appear on their behalf. Nicholls took the train to Launceston and Rule informed him of the way Dobbie was insisting that the enquiry be conducted. Nicholls then refused to appear, returned to Hobart and moved a motion of no-confidence in the Government in the House of Assembly, alleging that the choice of the three commissioners demonstrated the unfitness of the Ministers to remain in office. The motion was defeated 17-11 but Whitfield immediately resigned his commission because of Nicholls attack on his fitness and on the following day Dobbie and Young did the same.

Young publicly alleged[67] that many of the teachers had been persuaded to prefer charges against Neale by a few malcontents. However Young admitted that Neale occasionally 'said straight-out' what he meant, and Whitfield added that Neale had 'shown a great want of tact in some of his letters'[68]. Hamilton spoke with great praise of Neale's work, stating that standards in Tasmania were very low, and that reform was essential. 'Everything has yet to be done. You are scarcely yet beginning . . . It is a national calamity to find teachers so backward'[69].

It was clear that the discontent could not be allowed to rest there. Despite the trivia that had been presented it was presented with conviction and vehemence. It may have seemed that the teachers were using petty excuses to discredit their Director but there was no doubt that they felt strongly that he had no sympathy for them. Three weeks later the Government appointed Sir John Dodds, the Chief Justice of Tasmania, a Royal Commissioner. He discussed the matter with several teachers from 7 October to 12 October, and on the latter date he persuaded both the teachers and the Director to discuss the problems with him in Launceston.

Neale travelled to Launceston by train with N. K. Ewing[70], who had been asked by Rule to represent the teachers. Ewing told Neale[71] that none of Neale's proposals would be accepted by the teachers 'unless I sacrificed Inspector Brockett', who had loyally supported Neale, and unless 'Assistant-Inspector Crawford was sent back to a school'. Neale replied that he 'could not nor would for a moment consider any proposal to injure' Brockett or Crawford. Neale then suggested that he was willing to set up a Committee or Board of 'Classifiers', and agree to 'refer all appointments and promotions over £75 to the proposed committee', in the hope that this would dispel the fears of some teachers concerning their future. Ewing asserted that the teachers would not accept Brockett as a member, and that the Board should not only examine appointments but also regulations.

> 'I told Mr Ewing that I had been brought over to establish a system of Education and that I would not allow even the Inspectors to have a right of veto on any portion of the curriculum; that on this point my Australian reputation was at stake'[72].

The proposed Board was to have no executive authority but was able to submit to the Minister its recommendations on all matters concerning the classification, transfer or dismissal of teachers, and on all regulations relating to the duties of the teachers. Members of this Board were to be the four inspectors, four head teachers nominated by the Teachers Union, and the Director, as Chairman, with a casting vote as well as a deliberative vote.

The Chief Justice reported to Parliament on 12 November[73] that agreement to accept such a Board had been reached and that those at the conference had shaken hands all round. He recommended that the agreement should be submitted for parliamentary approval. Two weeks later Neale advised Ewing that he had obtained ministerial approval of a draft of the regulations concerning the duties of the Board of Classifiers, and claimed that he had contributed 'towards a full and amicable settlement'. Ewing replied: 'Indeed you have done your part and right loyally too. It is now all satisfactorily settled'.

The proposal that a Board should be established had been accepted by Evans and Propsting, but the draft of the regulations was neither submitted to Parliament nor considered by Cabinet. Evans and Propsting had reconsidered the proposal and had decided that it was improper and unreasonable that membership of the Board should be limited to men nominated by the executive of the Teachers Union, and improper that the Board or the Union[74] should have the sweeping influence that had been suggested. However, Evans and Propsting made

no effort to advise Parliament or the public of their new decision, and thus the teachers (and Ewing) believed that the Board had the authority that had been proposed and accepted at the meeting in Launceston.

Ewing, unaware of Evans's and Propsting's change of intention, wrote to Neale six weeks later, after several new regulations had been gazetted without any reference to the Board. 'It seems to me that the effect and intention of the establishers of the Board is that in all matters within its jurisdiction the Board is the real power and you have ceased to be such'[75].

Propsting admitted in Parliament in 1909 that the decision was 'entirely Ministerial action' and had not been prompted in any way by Neale, but because he and Evans allowed the impression to be given that the Board had certain authority, Neale's actions in directing the Department without reference to the Board was regarded as yet another arbitrary act by him, and the hostility created by this misunderstanding was considerable.

At the conference of the Teachers Union which began on 30 June 1908, the public became aware that the opposition to Neale, far from being soothed by the agreement made under the conciliation of Sir John Dodds, was stronger and more vehement than ever.

At first it was Neale's 'new education' that was attacked. The conference strongly criticised the introduction of drawing, singing and nature study to the curriculum by Neale, referring to the uselessness of these 'fads', and claimed that 'the work of a school was to teach boys the elements of a trade and girls how to cook'.

The president, J. J. Low, spoke bitterly against the innovations and against Neale's proposal that the child's individual needs should be studied. Low condemned such a notion. 'Individual teaching in a school or class of any size had long been obsolete'[76], he proclaimed, and the assembled teachers greeted this observation with loud applause.

Low also informed his members that the Board of Classifiers was 'the governing body' of the Department, possessing, 'subject to the Minister, the real administrative control of the Department'[77]. On the following day Low[78] claimed again that the Board was 'the real administrative control of the Department' and that it 'was to possess . . . the sole authority for the settlement of the question of making and rescinding old regulations', and criticised the 'distinct breach of faith' by which the Board's authority had been flouted by the gazettal of about '250 new regulations' in the previous six months[79].

Ewing, who had been invited to address the conference, with a flourish of rhetoric asked:

> 'What shall it profit a man, even if his wife does sing and play divinely, if the apple dumpling that she cooketh for his dinner sticketh in the middle of his anatomy? . . . If the State had any money to spare after teaching the three R's, then it should be devoted to giving the children still more practical education. Let them . . . guarantee to the children of the State that they will be able to spend the few years they can devote to school profitably, and not be sent away from school with a fancy education'.

Ewing 'engaged vigorously in condemning the cramming of school children with fancy education, to the neglect of what was essential and practical'[80]. His speech was punctuated by applause and when he finished he was cheered by all present.

The *Mercury* alleged that Ewing's speech was 'not unconnected with his political ambitions', deplored his attempt to secure votes by fomenting 'outright mutiny', and added:

> 'It must be a matter of regret that the Conference of State school teachers is being used as an opportunity for the emission of only half-stifled murmurs of rebellion . . . The President of the Association . . . practically invited the teachers to join in a movement of revolt'[81].

Neale had been consistently supported in his efforts to improve education by most of the newspapers of Tasmania and again they came to his defence.

> 'If we are to take the moss-covered utterances of the President as indicative of the Board's sentiments the new method of education is bosh, and the ancient calf-track method is just what is required. The Board, ambitious to dominate the department, has come to the conclusion that teachers must not be worried by new-fangled notions, so objects to everything which takes them out of the well-worn rut'[82].

The inspectors and the better-qualified teachers, many of whom were not members of the Union, were so disturbed by the attack on Neale that they met a fortnight later and expressed their

> 'fullest confidence in the Director of Education and his staff . . . We beg respectfully to submit that the re-arrangement of the curriculum within the last two or three years has made our schools bright both to the teachers and those taught, and has increased the mental activity and efficiency of the scholars'[83].

The twenty-five teachers who were present were unanimous in this opinion, and correspondence had been received from forty other teachers who supported Neale but who had been unable to attend the meeting. Commenting on the preference to members of the Union which had been demanded at the annual conference they added: 'Let there be preference, and let merit be the key to that preference'[84].

A few days after the conference of the Union had concluded Low led a deputation to the Minister, complaining that the Director was replying to complaints which had been sent to the Board of Classifiers, and not allowing the Board to settle the issues which were raised.

The Minister replied to the criticisms by the delegation three months later, in October. He characterised the complaints as either 'quite incorrect or sad misrepresentations' of the true

situation, and advised Parliament that the cause of the dissension in the Department was 'misapprehension and misunderstanding'. He expressed confidence in Neale and warned that 'a small group of discontented [teachers] without responsibitlity must not be allowed to control either policy or administration'[85].

To avoid such a situation, he announced that Dodds's recommendation a year previously that the Board of Classifiers should include four teachers elected from nominations submitted by the Executive of the Teachers Union would not be accepted, but that the teachers' representatives on the Board would be elected from those who were classified 1, 2 or 3. These were the teachers who were the most successful and best qualified; they were the men who had withdrawn from the Union, and who had met a fortnight after the conference to express support for Neale and his aims. It was clear that the Union could expect no support from the Minister. Even more resented by the Union than Propsting's decision to alter the method of electing the Board was the omission of any reference to the Union's chief complaint, that 'some teachers were much better treated than others . . . in the matters of remuneration particularly'[86]. This complaint was not answered and the inevitable assumption was that it was unanswerable.

Evans also supported Neale, claiming that the initial trouble would have been quickly forgotten 'if it had not been for the disloyalty of a few teachers'[87]. However, not even at this stage did the Premier or the Minister make it clear that they accepted the principle of ministerial responsibility for the administration of the Department. They gave no explanation of the authority that had been given Neale, and did not convince Parliament that it was not Neale who had been responsible for changing the method of election of the Board of Classifiers.

Ewing, resenting the repudiation of the agreement he had helped to formulate, wrote a long letter to Arthur Morrisby, M.L.C., which Morrisby read in the Council. The letter attacked every aspect of Neale's administration and alleged that the gulf between him and his teachers was unbridgeable. The Council demanded another Commission to resolve the issue and the Assembly, worried that the work of the Department was being affected by the dispute, supported the Council's proposal.

There was considerable disagreement concerning the membership of the Commission. The Premier at first suggested one member from each House, with a third member nominated by these two but, as usual, the members took little heed of him. Propsting strongly urged the inclusion of an educational 'expert', but this was opposed by many. 'Plain, practical men' but not 'theorists who will lose themselves in abstract ideas' were required, Propsting was advised, because it was not education but the administration of a government department that was to be examined. Therefore members of Parliament were said to be the logical commissioners, even though they 'may be biassed, as many of them have already expressed opinions'[88]. It would have been difficult to find members of either House who had not pre-conceived opinions on the questions which they were to judge. Most of them had reviewed in Parliament the reports of the two previous Commissions and some had spoken very strongly on various matters. Others were personally involved in the administration of education as members of Boards of Advice.

The final decision was to appoint five members of Parliament and, with Propsting remaining insistent, one educational expert, Peter Goyen, Chief Inspector of Schools in Otago, New Zealand.

Dr John McCall, M.H.A., was appointed Chairman of the Commission. He was Chairman of the Leven Municipality on the North-West Coast of Tasmania. He was not committed to a particular opinion concerning Neale and his selection as chairman was commended by all. However, McCall had been appointed Agent-General in London and was hoping for an early departure. As time passed McCall gave less attention to the affairs of the Commission than to the preparations for his voyage. The other members of the Commission were G. T. Collins, M.L.C., Ellis Dean, M.L.C., J. J. Long, M.H.A. and R. J. McKenzie, M.H.A. All four had been active in opposition to Neale ever since he was appointed[89]. Neale's fate was determined before the Commission met.

The teachers in the Department had again briefed Ewing to appear for them. Neale had no counsel when the Commission first sat, but sought representation when the gravity of his position was realised three weeks after evidence was first taken. Neale's counsel immediately criticised the latitude which had been allowed Ewing, who had called Neale as his own witness and then cross-examined him as a hostile witness, and sought to have many of the political and personal questions[90] by Ewing disallowed, but to no avail.

There was no reference in the terms of the Commission[91] to questions of curriculum, or to the skill and ability of the teachers. No reference to Neale's achievements or the difficulties that faced him was permitted.

Ewing's attack was concentrated solely and remorselessly on the propriety of the preference Neale gave to the South Australians and to his treatment of the Tasmanians. Ewing opened the proceedings by alleging:

> 'that the Department had been unfairly and improperly administered; that the public funds of the country have been given to persons in the employ of the Department almost exclusively South Australians in amounts that were not voted to them by Parliament; Tasmanian teachers have not received the money that Parliament voted for them . . .'[92].

Neale's defence at first was that he had appointed to the various positions the only teachers who were qualified to carry out the duties. All the South Australians were qualified, he claimed, and therefore entitled to appointment. On the other hand, only two Tasmanians were qualified, and these men were head teachers of country schools who were not willing to lose their status to become first assistants of larger city schools, even though this would eventually have led to a higher salary.

However, every South Australian who had been appointed was offered a salary higher than the maximum stipulated by Parliament and not one Tasmanian was being paid above the stipulated salary. Neale believed the appointment of trained teachers was essential, and he could only attract the South Australians by offering salaries that exceeded the approved scale. Some of them commenced as first assistants, a status which Neale created at this time, and others as assistants. These appointments and the allegedly preferential salaries which Neale gave to them were the basis of the charges made by Ewing. There were other allegations, e.g., that the South Australians were granted first-class train tickets when departmental business required them to travel to another town while Tasmanians had to travel second-class, but the salary questions dominated the Commission, and Neale was unable to deny the partiality of the salaries paid to the newcomers.

Neale claimed that he had discretionary authority because some regulations were ambiguous, and because other regulations had been 'suspended'. Later he admitted that the over-award payments were illegal but contended that many Tasmanians were also being paid more than they deserved. Nevertheless, he could not deny that the only teachers in his Department who were paid more than the stipulated salary for their classification were those who had been recruited by him from South Australia.

This point was the basis of Ewing's skilful and remorseless attack on Neale. Ewing claimed:

> 'that the foundation of the whole of this trouble has been caused by South Australians being placed over the heads of Tasmanian teachers with 10, 15 or more years service, at salaries up to £250, with increases[93]. . . . There is very bitter opposition to the importation of trained teachers[94], . . . the sole cause of complaint is that the South Australians are getting all the plums in the Department, that they are being advanced at a rate that the Tasmanians are not being advanced at'[95].

G. V. Brooks was the first of Neale's 'imports', and Ewing used Brooks's appointment and remuneration to illustrate his claims. Brooks had begun his service in the Education Department of Tasmania at the Battery Point School in Hobart as First Assistant in 1906 at a salary of £200 per annum. In the following year he received an increase in salary of £40. Neale justified this increase as a payment 'for special services in the capacity of headmaster for drawing at the Training College'[96]. Thus Brooks in 1907 was receiving £240 compared with £170 in Adelaide in 1905. Ewing attacked the initial salary of £200, which was £80 above the award, and the increase of £40 the following year, and Neale could only reply: 'I will admit that all these salaries are technically illegal . . . but what was considered the best course under the circumstances was pursued'[97].

In his final address Ewing stated:

> 'The position of the teachers [is that] in the interests of the children of this State we must have peace, and peace can only be achieved by getting rid of Mr Neale as head of this Department'[98].

The commissioners found[99] that Neale had acted improperly by paying higher salaries than permitted by the regulations, and that the former South Australians had been given privileges denied to Tasmanians in the Department. They also found that the tone and language of his correspondence with his teachers was 'provocative of irritation and entirely without justification' and that he had made deductions from the teachers due salaries and allowances by way of fine or penalty contrary to the regulations. However, their report mentioned their unanimous opinion that education in Tasmania had improved under Neale's direction, substantiated his contention that it had been essential to import good teachers to lift standards, and recommended: 'Something should be done, and done quickly, to staff the schools from top to bottom with competent teachers'[100].

The Commission recommended that compensation should be paid to those teachers who had been penalised by Neale, either by fines or by withholding allowances, and that the Boards of Advice should be granted greater authority than Neale had permitted them. The five commissioners who were members of the Tasmanian Parliament concluded their report:

> 'It is only just to Mr Neale that your commissioners should place on record their appreciation of his high ideals, his zeal, and his untiring industry; but they are of the opinion that, owing to the widespread discontent caused by faults in administration and treatment of teachers, as disclosed by the evidence taken, the retention of Mr Neale's services as Director would be distinctly detrimental to the best interests of the education system of the State'[101].

Peter Goyen submitted a minority recommendation:

> 'I agree with my colleagues in the findings and recommendations of the report but do not endorse the opinion expressed in the last part of the concluding paragraph'.

Goyen did not disagree with his fellow-commissioners' recommendation. He took the view that he had been appointed to the Commission to advise on matters beyond the experience of his colleagues and that he should not presume to submit any recommendation on the question of whether Neale should be retained or dismissed. His opinion of Neale's future usefulness to the State, however, was made known to Long, who published it. 'The enquiry destroyed his influence', and as a result Neale 'could do little to advance education'[102], Goyen wrote.

When Cabinet received the report of the commissioners, the Ministers could not agree on the action to be taken, and Neale was offered three months leave on full salary to allow them to discuss the matter without haste.

Evans and Propsting at first declined to accept the recommendation that Neale should be dismissed. Evans then agreed to do so, but Propsting did not. Evans and the other two Ministers then sought to avoid responsibility for coming to a decision by referring the matter to the Public Service Board. They were advised, however, that the Board could only act if Neale was formally

charged with an offence contrary to the Public Service Act. The three then enquired if Neale would accept payment of £1,200 to offer his resignation, rather than accept the legal difficulties which dismissal could incur[103].

Neale sought a greater amount, pointing out that he was too old at the age of 55 to gain another responsible position and that he had had to forfeit his superannuation rights when he left South Australia five years earlier. 'The task I was invited to undertake was too difficult to attempt without assurance of Parliament's support and protection', he claimed. As he had received no support from Parliament he felt that it was reasonable to expect a more generous recompense than £1,200.

The 1909 Assembly elections were held before Cabinet submitted any recommendations and before Parliament could consider the matter, but it was obvious from campaign statements that Neale could expect little consideration. Some candidates campaigned on a platform of 'dealing with Neale' and none was prepared publicly to support him. In fact, the growing strength of the Labour Party forced the non-Labour candidates to seek a common platform and Ewing, one of the candidates in Denison, with strong support from a few others, insisted on an anti-Neale policy as the price of unity.

The elections for the first time returned two parties, with twelve Labour members in a House of thirty forcing the other eighteen to unite as an 'anti-socialist party' in order to hold office. Evans had been strongly criticised by his colleagues for his weak and ineffectual control of the Education Department when he was Minister, and he did not seek re-election as Premier. Neil Elliott Lewis replaced him and Lewis appointed A. E. Solomon, newly elected to Parliament, as Minister for Education[104] in place of Propsting.

When Parliament met, Ewing, now a member for Denison, attacked Neale and urged that no compensation should be paid to him. J. A. Lyons, a former teacher in the Education Department, had been elected as one of the Labour representatives of Wilmot, and claimed that he was in Parliament 'as the representative of the teachers'[105]. He took the same view as Ewing. Solomon, with no parliamentary experience and no detailed knowledge of the Department, was forced to lead the debate. He sought to bring it to a conclusion without embarrassing the former Ministers or the officers of the Department, and without unfairness to Neale. Solomon's wisdom, fairness and integrity impressed everyone. Some members supported Ewing and Lyons, but most believed that it was better to pay Neale compensation. As Lewis said: 'The Government wanted to devise the cheapest way to get rid of Mr Neale'[106]. Most members condemned him bitterly and those who did not do so agreed that the teachers would not work under his direction, and that he must leave to ensure that peace and harmony were restored. The proposal to pay him £1,200 was passed 15-10 in the House of Assembly, with the Labour members opposing the motion and demanding a smaller amount or none at all. The proposal was passed 8-3 in the Council.

Neale accepted the offer of £1,200, resigned his position and returned to South Australia. He sought re-appointment as an Inspector in the Education Department of South Australia and although the Director supported his application, Cabinet refused it. Neale subsequently accepted a clerical position in the Federal Land Tax Department in Adelaide. In December 1913, he suffered a stroke and died at the age of 60. His obituary notice in the *Mercury* summarised his career in Tasmania: 'He made the mistake of becoming somewhat over-zealous'[107]. It was almost a repetition of earlier criticism that he 'appeared to be in haste to jump from the extreme of laxity . . . to the other extreme of severity'[108].

Neale had greatly reduced the chaos he found in the Department in 1904, had increased the number of teachers by about 8%, and the number of inspectors, had increased teachers' salaries[109], had increased attendance by more than 20%, had established a Training College, had built nearly thirty more schools, had broadened and modernised the curriculum, and had increased expenditure only from £62,442 in 1904 to £65,064 in 1908 while doing so.[110].

Neale had been invited by the Government to accept the position of Director and Evans had promised him 'as free a hand in administration as can be granted'. In addition, when Neale warned Evans even before he arrived that his innovations would lead to demands for a Royal Commission, Evans promised that 'three experts from the mainland States' would be appointed 'when the inevitable Commission came'[111]. Neither promise was kept. Evans gave Neale freedom, responsibility and authority, but never guidance, protection or support. Evans may have assumed that these factors were synonymous, and Neale may have welcomed unfettered control of the Department, but later events proved that he was unwise to exercise it. It was in Parliament that Neale needed support. Too few Tasmanians desired a better system of education or were aware of the deficiencies of their own system. There was no strong public opinion to force Parliament to support the Director. It was therefore essential that the Premier and Minister should not only defend Neale, but also seek to convince Parliament and public of the advantages to the State that Neale's innovations would bring. When they failed to do so Neale was left at the mercy of his opponents.

His strongest opponents were the members of the Boards of Advice in rural areas. These were the landowners, the employers of labour accustomed to order the affairs of their district without interference. But these men were also the representatives of their district in Parliament where their grievances against Neale were fanned by constituents who feared the loss of cheap child-labour if Neale's truancy laws were enforced. Neale was also opposed by the unqualified teachers, particularly those who had been humiliated by his unfortunate manner. The older feared to lose their employment or income and did not understand the new curriculum; the younger imagined that promotion opportunities would be lost to the 'imports' from South Australia.

Underneath the discontent was an uneasiness that the 'imports' were likely to overturn the Tasmanian conservatism. There was suspicion of the vigorous enthusiasm of the South Australians, recruited to newly-created positions of influence in the Education Department by a Director from the same State who was not concerned with local traditions and who had been appointed by a Premier who had been educated in the same State.

An entrenched conservatism, suspicion of 'foreigners' and a lack of vital interest in education would have made Neale's task extremely difficult, whatever other circumstances applied. His own peremptory manner and the failure of Evans and Propsting to accept ministerial responsibility for his actions left him at the mercy of his enemies. His ability was outstanding and his resignation a tragic blow to Tasmania. Education was forgotten as personality and prejudice occupied the attention of Parliament, and without any public demand for education the lack of political attention ensured that progress was limited.

References and Notes

1 Propsting was a Tasmanian who went to South Australia in 1879 to gain a better training in the teaching profession than was available in his own State. During his career in South Australia he taught in two schools where W. L. Neale was Head Teacher, and he formed a very high regard for Neale's ability. Propsting returned to Tasmania in 1886, foresook teaching for law and was elected to the House of Assembly in 1899.

2 W. L. Neale, *Report on the System of Primary Education in Tasmania*, J PP, Vol L1, 1904, No. 49.

3 These nineteenth century educational philosophers differed from each other in emphasis, but all stressed the importance of the personality of the child and the environment in which he learns, and all opposed the rigid, formal drill that was common in most educational systems.

4 W. L. Neale, *op. cit.*, p. 21.

5 W. L. Neale, *op. cit.*, p. 61.

6 Propsting had been able to command the support of a majority of the House of Assembly but was rebuffed on several occasions in the Legislative Council. In July 1904, after an Assembly Bill was rejected by the Council he sought to force the issue by resigning, expecting the Governor to recall him. However, the Governor asked Captain J. W. Evans, a retired merchant navy skipper, to form a government. Evans did so, assuming office as Minister for Education as well as Premier.

7 Masters's appointment was simply one of expediency. 'Between the years 1905 and 1910 he had no duties'. (W. T. McCoy, Neale's successor, T.S.A., File 0269, 1919.)

8 The Education Act of 1885 had created forty-four Boards of Advice, replacing the Public School Boards which had been first appointed in 1868. The Boards had no power to interfere with the operation of the schools, but had authority to effect petty repairs and to control the use of buildings after school hours. They were required to persuade parents to send their children to school regularly, to institute legal proceeding against those who failed to do so and to reduce or abolish fees in the case of needy parents. The Hobart Board of Advice was elected but the other Boards were the municipal councils, sitting as education authorities.

9 The Council felt so strongly that Neale should not have been appointed that provision in the budget for his salary was deleted by the Council. Provision for a salary of £450, instead of £600 that had been offered to Neale, was subsequently approved by the Council, and after further delay approval to pay £600 was granted, but only by a 9-3 vote of the Council with six members not voting at all.

10 T.S.A., Education Department files, 1904.

11 *Examiner*, 27 September 1904.

12 *Examiner*, 1 November 1904.

13 *Examiner*, 11 November 1904.

14 *Examiner*, 21 August 1905.

15 It was not until after Neale's arrival in Tasmania that there is any reference in the files of the Education Department to questions of curriculum or text books. The first evidence of interest in the curriculum by parents or civic organisations was a request in 1905 by the Council of Agriculture that the teaching of decimals should be introduced, and this was not prompted by anything more than a desire for children to be proficient 'in the use of the Babcock Milk Tester'. (T.S.A., File 749, 1905.)

16 W. L. Neale, *op. cit.*, p. 51.

17 Each 'school' was one room.

18 Elkington had offered to have the cost borne by his own department if ministerial consent for the scheme could be obtained, but Neale advised his Minister that 'the proposed work was of the highest importance' and finally persuaded the Minister to grant £70 for this purpose. The grant was charged against the vote for 'Maintenance of Schools', because it was felt that Parliament would not sanction additional expenditure for such a purpose.

19 Peterson had conducted physical culture courses in Hobart since 1902, capitalising on public concern that volunteers for the South Afrian War were not physically fit. He had also organised and conducted Saturday morning classes for teachers who were cadet instructors.

20 Neale's efforts in this field were stimulated by the Prime Minister, who convened a conference of representatives of all State Education Departments in 1905 to urge the introduction of compulsory physical and military training in the schools. The training began in May 1906, but was greatly hindered by the shortage of competent instructors.

21 These officers were supposed to visit each school in their town once each week, but this was often not possible, and no other towns were ever visited. They conducted an examination of children submitted for inspection by the head teacher when they visited the school, and were responsible for the hygiene of the schools as well as the health of the children. Despite the limited nature of the scheme it paved the way for future expansion, and was the first such scheme in Australia, following closely on the establishment of a similar scheme in England.

22 During 1908, when the correpondence columns of the newspapers were enlivened by a controversy as to whether a majority, or only a few, of the children attending State schools were infected with lice, *The Educational Record* redoubled the attention it gave to questions of cleanliness and hygiene.

23 *Mercury*, 12 December 1908.

24 *Rep. Dir.*, 1907.

25 T.S.A., File 314, 1906.

26 *Mercury*, 29 April 1907.

27 The Legislative Council in 1907 had disallowed an Assembly Bill to abolish fees. The Government by regulation then reduced fees to such a low level from the beginning of 1908 that the State's revenue from this source fell from £12,000 p.a. to £5,000 p.a. The Council accepted a similar Bill in November 1908.

28 The students who entered the College were required to sign an undertaking that they would remain in the service of the Department for four years after completing their College training, or to pay £1 10 0 for each month of the unexpired period if they left before four years had passed.

29 The establishment of a Training College was possible only because of a bequest by the late Philip Smith in 1876. The bequest had not been used and the principle had grown to £2,050. To this was added a gift of £500 by Miss Marion Smith, Philip Smith's sister, and the Government contributed £4,575 from General Revenue. This left the total £600 short of the actual cost of £7,725 but Neale persuaded the Minister to allocate £600 of the 1906-07 vote of the Education Department to provide the full amount needed to build the College.

30 When several tennis courts were erected at the College the money to pay the contractor was taken from the School Bank Account, because the Minister was not prepared to ask Parliament to authorise the expenditure.

31 26 Ed. VII, 22 November 1907.

32 The Scholarship Act provided an allowance of £15 per annum for three years and £25 per annum in addition if the pupil had to live away from home in order to continue his education. The awards were made on the results of examinations open to children under the age of thirteen years. In addition, exhibitions were awarded on the results of the Junior Public examinations to children under the age of 15 years. They were valued at £20 per annum for three years and thus assisted children to the stage where they were eligible to enter University. The cost to the State was £855 per annum. Because the Act was drawn up at a time when State secondary schools had not been contemplated the awards were tenable only at non-State schools or at the Training College.

33 Many of these schools were merely havens of refuge from the truant officers, enrolling children whose parents paid the prescribed fees, but not caring whether the children attended classes. Non-State schools had been required to submit returns from 1897, but the State could not enforce the requirement because proprietors were not required to register their schools. Therefore Neale was unable to prevent or punish the virtual truancy of pupils who were enrolled in the non-State schools but who did not attend classes.

34 Registration of Teachers and Schools Act, No. 15, 6 Ed. VII, 25 October 1906.

35 Wilkinson's only complaint was that Neale had used the phrase 'private schools' to refer to all those schools that were not State schools, whereas there were five schools in Tasmania—Launceston Church Grammar School, The Hutchins School, The Friends School, The Collegiate School and the Launceston Ladies College—which Wilkinson claimed should be given the status and title of Public Schools and not classified as 'private'.

36 No. 26, 5 Ed. VII, 20 November 1905.

37 The benefits were so modest that a teacher who retired in 1936 after forty-four years service received an annuity of only £116, but the scheme's significance at the time lay in Neale's desire to establish it for his teachers.

38 Evans had gone to sea as a cabin-boy at 14 years of age when many of his contemporaries were at primary school, and after his retirement he became manager of a Hobart shipping company. He had preferred not to become too concerned with the affairs of the Education Department. Neale was his first mate and was left to control the ship's course.

39 Neale, *op. cit.*, p. 52.

40 The Premier, Evans, claimed in 1909 that this was a Cabinet decision reached with the knowledge and approval of Crosby Gilmour, who had been Solicitor-General at that time. Gilmour vehemently denied any knowledge of such a proposal, and another Cabinet Minister of the time said he did not remember any discussion on the subject. Propsting stated in 1909 that the regulations had been 'suspended' in order to protect the teachers from reductions in salary that would have resulted if the regulations had been applied. Until 1900 it was the responsibility of the teachers to collect the fees, which were retained by them and regarded by the Department as part of their salaries. New regulations which took effect from the beginning of 1901 provided that fees would be collected by teachers but paid into the Treasury, and that the salaries of the teachers would be increased by the amount of fees they surrendered in 1900. This led the teachers to strive vigorously to collect not only the 1900 fees but also considerable arrears. The fees collected in 1899 were £10,948, in 1900 they were £12,156 and in 1901 £10,735. The incorporation of the magnified 1900 collections into a permanent salary reduced to chaos the salary regulations of the Department.

41 *Mercury*, 15 July 1909.

42 *Examiner*, 6 December 1905.

43 The Teachers Union had been formed in 1905, although there had been occasional meetings of teachers as long as twenty years earlier. These early meetings were remarkable for the very small attendances at meetings and the very great enthusiasm of the few who did attend.

44 *Examiner*, 3 October 1905.

45 Most of these teachers were aged about 30, with considerable experience and yet still active. Three of them were graduates, and all had received some teacher-training. Only two of the twenty-six were women.

46 Brockett was an Inspector when they arrived and later Senior Inspector.

47 *Educational Record*, 15 April 1907, p. 1.

48 This was the Beaconsfield School, where the Head Teacher and the First Assistant were both South Australians.

49 *Rep. Dir.*, 1906, p. 3.

50 *Mercury*, 19 April 1907.

51 T.S.A., Education Department Files, 1907.

52 These penalties varied from 5d. to £6. They were bitterly resented by the teachers.

53 Neale's inspection of the Newnham School in 1907 revealed that only two of the forty-four children were able to get a single sum right in their annual examination, and this was not an unusual situation.

54 Neale reported to his Minister in 1906 that 'since the weather has improved there is an increase of teachers'. (T.S.A., File 832, 1906.)

55 T.S.A., Education Department Files, 1908.

56 The article alleged that the local school had only one room, 25 feet x 15 feet, in which one teacher attempted to cope with forty-nine children in seven different grades.

57 T.S.A., Education Department Files, 1907.

58 There is no doubt that Neale's criticism was justified. The report of the Head Teacher of the Northdown School in 1908, defending the poor record of achievement of his pupils, explained: 'The children are engaged in picking up potatoes. Mr Bray's boy will be 9 years old in October, and has had less than sixty-four days at school altogether'. (T.S.A., Education Department Files, 1908.)

59 *Rep. Dir.*, 1906.

60 The hop fields in the Derwent Valley and the mutton bird rookeries in Bass Strait depended heavily on child labour, but other areas were also affected.

61 His communications to the Boards often gave offence, even when he was trying to assist them. On one occasion he queried the authorised purchase of 25 tons of firewood for a school with one fireplace, pointing out bluntly that the average consumption was 4 tons per year. The Board replied that it was 'not in the habit of making mistakes'. (*Mercury*, 13 April 1907.)

62 *Mercury*, 20 April 1907.

63 *Mercury*, 9 July 1907.

64 *Mercury*, 26 July 1907.

65 *Mercury*, 27 April 1907.

66 One teacher alleged that he and an assistant had to teach 127 children but admitted Neale's comment that the teacher shared this responsibility by teaching nineteen children while his assistant taught 108. Another alleged that Neale altered his [the teacher's] classification of students but admitted Neale's comment that the teacher had kept children aged 15 years in Grade I to improve his examination results. Another alleged that Neale refused to pay her for duties she had carried out beyond a certain date but agreed with Neale's comment that he had given her clear and adequate notice that her employment would cease on that date because of her approaching confinement. Another complained that Neale, through personal vindictiveness, had refused to appoint his son as a cadet instructor but agreed with Neale's comment that the son was aged 13. A lady complained that she had not been paid for her work as secretary of the local Board of Advice but agreed with Neale's comment that the Board had ceased to meet by its own decision.

67 *Mercury*, 9 September 1907.

68 *Mercury*, 11 September 1907.

69 T.S.A., Education Department Files, 1907.

70 Ewing had been elected to the first Commonwealth Senate in 1901 when he was living in Western Australia. He was then aged only 31. He resigned from the Senate in 1903, and soon afterwards set up legal practice in Tasmania. By 1907 he was seeking an opportunity to re-enter politics, and had actively supported the criticism of Neale by the discontented teachers. His vigorous rhetoric ensured publicity for the cause he had espoused.

71 On reaching Launceston Neale wrote an account of his conversation with Ewing in the train. There is no supporting evidence to prove that Neale's version is correct, but not even during his least popular moments was Neale ever accused of dishonesty, or of refusing to face an issue, and there is no reason to believe that the account is incorrect.

72 T.S.A., Education Department Files, 1907.

73 J PP., 7 Ed. VII, No. 49.

74 Most of the better-qualified teachers had withdrawn from the Union by this time because of disagreement with its aims and its attack on Neale. Thus the head teachers on the Board would be agents of a Union which was representative only of the less qualified teachers.

75 T.S.A., Education Department Files, 1908.

76 *Mercury*, 1 July 1908.

77 *Ibid.*

78 There was some opposition to Low. R. E. Smith, who had not been permitted to have his name placed on the ballot paper when the election of the Union's representatives to the Board of Classifiers was held, attacked the President forcefully. He referred to the injustice of the action of the Union's Executive, which had vetoed the nomination of candidates opposed to their point of view, and moved disagreement with their policy. Low, however, refused to put the motion to the meeting.

79 *Mercury*, 2 July 1908.

80 *Mercury*, 1 July 1908.

81 *Mercury*, 2 July 1908.

82 *The Weekly Courier*, 9 July 1908.

83 *Mercury*, 20 July 1908.

84 *Mercury*, 20 July 1908.

85 *Mercury*, 14 October 1908.

86 *Mercury*, 10 August 1908.

87 *Mercury*, 29 October 1908.

88 *Mercury*, 28 October 1908.

89 Collins had opposed Neale's proposal that fees should be abolished by claiming that the only people who wanted free education were those who could not afford to pay for it (*Mercury*, 31 October 1907). Dean was a very conservative Chairman of a Board of Advice. Both of them had expressed opposition to Neale's appointment in 1904, they had led a move to delete provision for his salary from the estimates for 1904-05, they had obtained the appointment of a Select Committee to examine the validity of his original report on the affairs of the Department, and they had criticised him on subsequent occasions. Long had voted against the Government on several censure motions concerning its education policies and had expressed 'the greatest contempt' for the Solicitor-General and his actions when he was Chairman of the first Commission. McKenzie had voted against the Government in 1907, when censure of its appointment of the first Commission was proposed. Both had been active in opposition to Neale throughout his career.

90 Ewing sought every opportunity to discredit Neale, even to allegations of improper motive in introducing a first-grade primer in which an illustration showed a lady not completely dressed.

91 Royal Commission on the Education Department of Tasmania, J PP, Vol. LXI, 1909, No. 1.

92 Evidence presented to the Royal Commission, *loc. cit.*, p. 1.

93 Evidence presented to the Royal Commission, *loc. cit.*, p. 5.

94 *Loc. cit.*, p. 29.

95 *Loc. cit.*, p. 624.

96 *Loc. cit.*, p. 3.

97 Evidence presented to the Royal Commission, *loc. cit.*, pp. 3-4.

98 *Loc. cit.*, p. 697.

99 The Premier had expected the Commission's enquiries to last only for a few days but in fact the members sat on forty-three days between 11 January and 2 March 1909. It heard more than 800,000 words of evidence and presented its report and recommendations on 12 March.

100 Report of the Royal Commission *loc. cit.*, p. viii.

101 Report of the Royal Commission, *loc. cit.*, p. x.

102 *Mercury*, 25 July 1909.

103 No charge had yet been brought against him under the terms of the Public Service Act and it was doubtful if any charge could be sustained.

104 Solomon was the first Minister for Education who had attended a State school.

105 *Mercury*, 9 July 1909.

106 *Mercury*, 9 July 1909.

107 *Mercury*, 17 December 1913.

108 *Mercury*, 15 November 1907.

109 Between Neale's appointment at the beginning of 1905 and the latter half of 1907 the average salary of male head teachers had increased from £155 to £166, of female head teachers from £91 to £98, of male assistants from £130 to £144 and of female assistants from £52 to £63.

110 The increased attendance had actually caused the expenditure for each child to fall from £4 7 2 per year in 1904 to £4 1 7 per year in 1908.

111 South Australian Archives. Education Department, 2390 of 1909.

[*Manuscript received 28 September 1969*

SOME TASMANIAN CHTHONIID PSEUDOSCORPIONS

By

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(With three figures)

SUMMARY

Four species of pseudoscorpions of the family Chthoniidae are recorded from Tasmania. Two cave dwelling forms are new species whilst another is shown to possess an extensive distribution throughout Tasmania and southern Australia. Descriptions of the new species are given, a key to the known Tasmanian species provided and a map included to show the localities from which material has been taken.

INTRODUCTION

The pseudoscorpion fauna of Tasmania is little known and only three species appear to be recorded from the island with any certainty (Morris, 1947; Beier, 1966). The efforts of various people have enabled me to examine specimens of pseudoscorpions of the family Chthoniidae from throughout the State. I am indebted to Emeritus Professor V. V. Hickman who placed his collections in my care and Professor M. Beier for his advice. My thanks are proffered to the members of the Southern Caving Society and the Tasmanian Caverneering Club who have collected for me. It is hoped that recording their names with the material that they have collected will be sufficient acknowledgment.

Twelve Australian species of Chthoniidae are known to date, included in five genera (Beier, 1966, 1968). The Tasmanian material to hand adds two new species to the list and extends the known distribution of another. Including the two new species, six Australian chthoniid pseudoscorpions are now known from caves.

A key to the chthoniids known to occur in Tasmania is provided and a map to show the localities from which the material was collected is included.

SYSTEMATIC ACCOUNT

Order PSEUDOSCORPIONIDA

Family CHTHONIIDAE

Genus AUSTROCHTHONIUS Chamberlin

Chamberlin, J. C., 1929.—*Ann. Mag. Nat. Hist.*, (10) 4: 50-80.

Austrochthonius australis Hoff

Hoff, C. C., 1951.—*Ann. Mus. Novit.*, 1483: 1-13; Beier, M., 1966.—*Aust. J. Zool.*, 14: 281-283.

Material examined: Two tritonymphs, three deutonymphs. Battery Point, Hobart, Tasmania; under stones and garden debris; 18.I.1969. Mrs T. Goede leg. Tasmanian Museum Reg. No. J612.

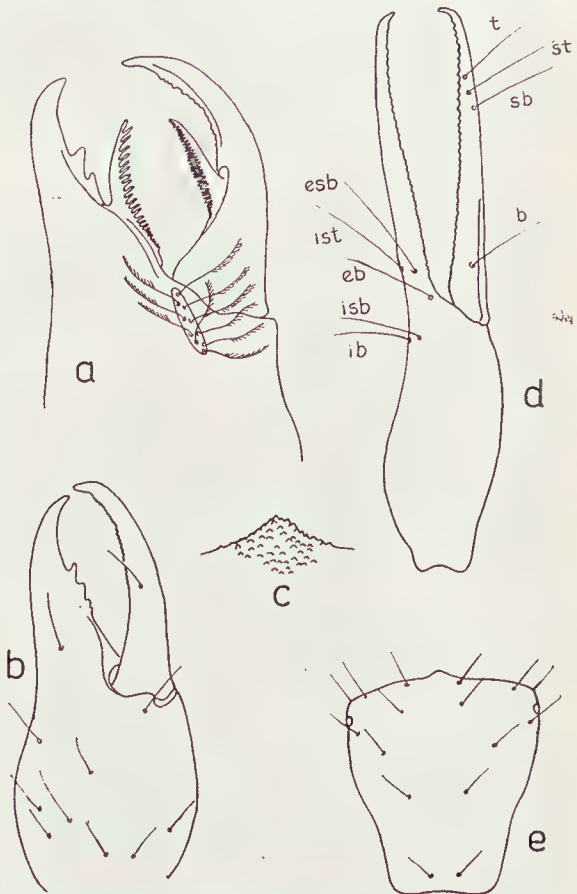

FIG. 1.—*Pseudotyrannochthonius tasmanicus* sp. nov. Holotype ♂
(*a*) Chelicera showing flagellum and lamellae.
(*b*) Chelicera showing setae of hand.
(*c*) Epistome.
(*d*) Pedipalpal setae.
(*e*) Carapace.

Comments: These specimens add little to the descriptions offered by both Hoff and Beier. Previously recorded in Tasmania, by Beier, from Grove and Mt Wellington in wet sclerophyll forest.

Genus **PSEUDOTYRANNOCHTHONIUS** Beier

Beier, M., 1930.—*Boll. Lab. Zool. Gen. Agr. Portici.*, **23**: 197-209; 1966.—*Austr. J. Zool.*, **14**: 285-288.

Pseudotyrannochthonius tasmanicus sp. nov.

(Fig. 1, *a-e*)

Description of holotype: Light brown in colour, chelicerae and pedipalps darker than the rest of the body. Carapace slightly longer than broad, strongly narrowed caudally and with a pronounced triangular, dentate epistome on the anterior margin. Sculpture of the carapace very finely dentate especially near to the lateral margins. The disc carries sixteen bristles of which 6 are on the anterior border and 2 near the hind margin.

A small pair of eye lenses are present. (Eye lenses are absent in one specimen, J614.) Eyes absent.

Chaetotaxy of the abdominal tergites 2. 4. 4. 6. 6. 6. 8. 8, etc.

Chelicerae broad and heavy carrying nine bristles on the palm. Flagellum of ten bristles arranged in two rows on a large areole. Fixed cheliceral finger with three distinct teeth followed proximally by a smaller tooth. Moveable finger heavily thickened along the inner edge. Without a spinneret hump.

Pedipalps long and slender. Femur about 0.85 times the length of the chela. Moveable finger about 1.1 times the length of the hand and carrying some fifteen teeth distally and about thirty blunt serrations along the proximal half of the finger. Fixed finger with about forty simple teeth.

Tactile setae *ib* and *isb* dorsodistally on the palpal hand. Setae *sb*, *st* and *t* grouped in an oblique line on the distal third of the moveable palpal finger. The distance between *sb* and *b* is about four times the distance between *sb* and *t*.

The coxae of the pedipalps carry two spines. Coxae of the walking legs spined as follows: i. 7, ii. 6, iii. 5, iv. 5. The coxae of the first pair of walking legs also carry a row of seven coxal spines of typical fascies on the forward margin. A bisetose intercoxal tubercle is not present.

Measurements of the holotype: Body length 3.0 mm, carapace length 1.1 mm, greatest width of carapace 1.0 mm, posterior width of carapace 0.8 mm, length of chela 2.1 mm, cheliceral length 0.7 mm, breadth of cheliceral palm 0.4 mm.

Type locality: King George V Cave, SE Tasmania. Map reference 4756/6597 Southport topographic sheet 8211/II/S.

Holotype: One ♂. King George V Cave, SE Tasmania. About 300 feet inside cave and c. 6 feet above water level in stream passage; amongst organic debris in discarded rubber glove. 22.VI.1968. Mrs T. Goede leg. Tasmanian Museum Reg. No. J613.

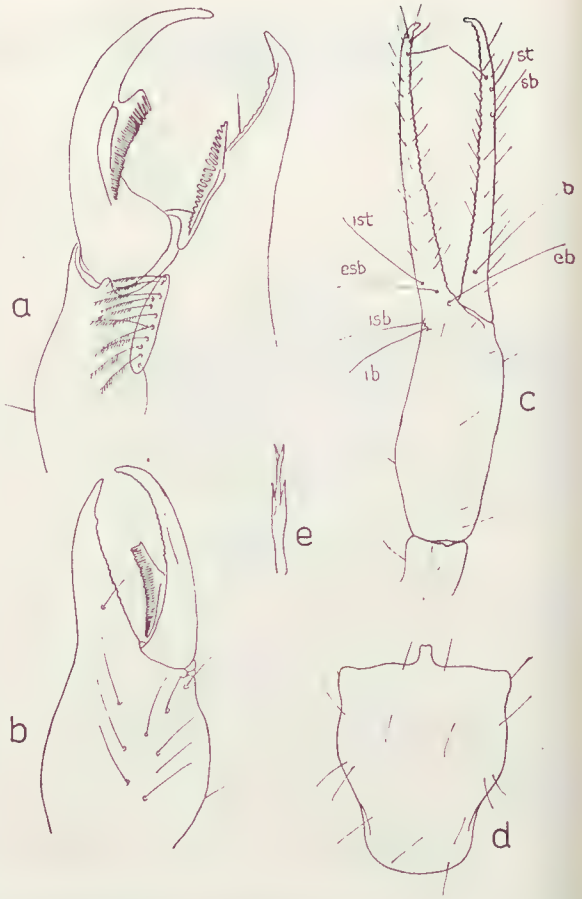

FIG. 2.—*Pseudotyrannochthonius typhlus* sp. nov. Holotype ♂
(*a*) Chelicera showing flagellum and lamellae.
(*b*) Chelicera showing setae of hand.
(*c*) Pedipalpal setae.
(*d*) Carapace.
(*e*) Single coxal spine.

Paratypes: One ♀. Outside King George V Cave, SE Tasmania; under log in wet sclerophyll forest. 24.III.1969. Mrs T. Goede leg. Tasmanian Museum Reg. No. J614.

One ♀. King George V Cave, SE Tasmania. In main chamber in discarded matchbox. 24.III.1969. B. P. Moore leg. Tasmanian Museum Reg. No. J615.

One ♀. King George V Cave, SE Tasmania. In main chamber under cigarette paper. 24.III.1969. A. Goede leg. Tasmanian Museum Reg. No. J616.

Comments: In spite of the absence of an intercoxal tubercle in this form this author feels that on the chaetotaxy of the palpal hand, coxal area and tergites the new species can be placed in no other genus.

FIG. 3.—Map of Tasmania showing localities mentioned in the text.

*Pseudotyrannochthonius typhlus** sp. nov.

* Typhlus is derived from typhlos (Gk) = blind (Fig. 2, *a-e*)

Description of holotype: Carapace finely sculptured, nearly equal in width to the length, strongly narrowed caudally. Disc with sixteen strong bristles all arranged singly except for a pair situated medially on each lateral margin. Anterior margin of carapace more or less straight with a slight concavity towards the antero-lateral angle. A large epistome is present, finely granulate and depressed in the long axis with the lateral borders raised.

Eyes and eye lenses absent.

Chaetotaxy of the abdominal tergites 2. 4. 4. 4. 6. 7. 6. 8, etc. Two bristles missing from tergite seven in the holotype.

Chelicera broad and heavy, with lightly squamoid sculpturing and bearing ten bristles on the palm. Flagellum of twelve bristles arranged in two close rows upon a large areole; each flagellar bristle carries fine rami along one side for the distal half of its length. Fixed cheliceral finger with one strong tooth distal to a bluntly serrate ridge of some fifteen small teeth. Moveable finger with numerous blunt serrations. Without a spinneret hump.

Pedipalps slender. Femur a third as long again as the carapace and three-quarters the length of the chela. Moveable finger about 2.3 times the length of the hand, carrying twenty-eight simple teeth distally and a ridge with ten blunt serrations proximal to the articulation. Fixed finger with thirty-five simple teeth. Tactile setae *ib* and *ist* situated dorsodistally on the hand on small tubercles. The distance between setae *sb* and *b* about four times the distance between *sb* and *t*.

The coxae of the pedipalps carry three spines. The coxae of the walking legs are spined as follows:—i. 7, ii. 5, iii. 5, iv. 5. (In the holotype two spines are missing from the coxa of the second left walking leg and one missing from the coxa of the third left leg.) The coxae of the first pair of walking legs carry a row of fifteen spines standing near the anterior margin.

A bisetose intercoxal tubercle is present.

Measurements of holotype: Body length 2.8 mm, carapace length 1.0 mm, greatest width of carapace 1.0 mm, posterior width of carapace 0.7 mm, length of chela 2.6 mm, cheliceral length 1.2 mm, breadth of cheliceral palm 0.5 mm.

Type locality: Sennacheribs Passage, Georgies Hall Cave, Mole Creek, Tasmania. Map reference 364/766 Middlesex, zone 7, sheet 45.

Holotype: One ♂. Sennacheribs Passage, Georgies Hall Cave, Mole Creek. On moist sand and vegetable debris in stream passage. 27.I.1968. A. Terauds leg. Tasmanian Museum Reg. No. J602.

Paratypes: One deutonymph. Sennacheribs Passage, Georgies Hall Cave, Mole Creek, Tasmania. 27.I.1968. Collected with holotype. A. Terauds leg. Tasmanian Museum Reg. No. J603.

One tritonymph. Baldocks Cave, Mole Creek, Tasmania. In wood debris on clay bank near cave stream. 17.IV.1968. A. Goede leg. Tasmanian Museum Reg. No. J611.

Pseudotyrannochthonius solitarius (Hoff)

Tubbichthonius solitarius Hoff, C. C., 1951.—*Am. Mus. Novit.*, **1483**: 10-13.

Pseudotyrannochthonius solitarius Beier, M., 1966.—*Aust. J. Zool.*, **14**: 286.

Material examined: Four ♀♀, four ♂♂. Liffey Falls, Tasmania. In moss and fallen leaves. 14.V.1953. V. V. Hickman leg. Tasmanian Museum Reg. No. J617.

Four deutonymphs. Mount Wellington, Tasmania. Under stones at an altitude of 1,000 feet. 30.IX.1947. V. V. Hickman leg. Tasmanian Museum Reg. No. J618.

One deutonymph. Lenah Valley, near Hobart, Tasmania. In grass tussocks. 26.V.1937. V. V. Hickman leg. Tasmanian Museum Reg. No. J620.

One ♂, four tritonymphs. Trevallyn, Launceston, Tasmania. In ants nest under stone. 20.IV.1928. V. V. Hickman leg. Tasmanian Museum Reg. No. J619.

Five tritonymphs, two detuonymphs. Fingal Tasmania. Under stones and amongst moss. 24.V.1928. V. V. Hickman leg. Tasmanian Museum Reg. No. J622.

One detuonymph, twenty-one protonymphs. Punchbowl, Launceston. Tasmanian Museum Reg. No. J621.

Distribution: Previously recorded from Victoria and SW Australia. Now known from Tasmania.

Affinities of the Tasmanian species of Pseudotyrannochthonius: Both *P. typhlus* sp. nov. and *P. tasmanicus* sp. nov. appear to be most closely related to *P. jonesi* (Chamberlain), a cave dwelling species from New South Wales. All are large forms and can be distinguished from each other by the number of teeth of the moveable palpal finger.

KEY TO THE KNOWN SPECIES OF CHTHONIIDAE IN TASMANIA

Pseudoscorpions with two pairs of forelegs with one tarsal joint; the two pairs of hind legs with one tarsal joint.

1. Tactile setae *ib* and *isb* near the middle of the forsum of the palpal hand; coxal spines present on the coxae of the second pair of legs .... — *Austrochthonius australis* Hoff

   Tactile setae *ib* and *isb* distally on dorsum of the palpal hand; coxal spines present on the coxae of the first pair of legs .... — *Pseudotyrannochthonius* Beier (2)

2. Moveable palpal finger with ten teeth distally .... — *Pseudotyrannochthonius solitarius* (Hoff)

   Moveable palpal finger with more than ten teeth distally .. .. — (3)

3. Fixed cheliceral finger with three conspicuous teeth — *Pseudotyrannochthonius tasmanicus* sp. nov.

   Fixed cheliceral finger with one conspicuous tooth .... — *Pseudotyrannochthonius typhlus* sp. nov.

Bibliography

Beier, M., 1966.—On the Pseudoscorpionidea of Australia. *Aust. J. Zool.*, 14: 275-303.

————, 1968.—Some Cave Dwelling Pseudoscorpionidea from Australia and New Caledonia. *Rec. S. Austr. Mus.*, 15 (4): 757-765.

Chamberlin, J. C., 1962.—New and little known false scorpions, principally from caves, belonging to the families Chthoniidae and Neobisiidae. *Bull. Am. Mus. Nat. Hist.*, 123.

Hoff, C. C., 1951.—New Species and records of chthoniid pseudoscorpions. *Am. Mus. Novit.*, 1483: 1-13.

Morris, J. C. H., 1948a.—The Taxonomic Position of *Idiogarypus Hansenii* (With). *Proc. Roy. Soc. Tasm.* (1947): 37-41.

————————, 1948b.—A new Genus of Pseudogarypin Pseudoscorpions Possessing Pleural Plates. *Proc. Roy. Soc. Tasm.* (1947): 43-47.

[*Manuscript received 17 September 1969*

A NEW SPECIES OF *BONELLIA* (ECHIUROIDEA) FROM NORTHERN TASMANIA

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(With four text figures)

ABSTRACT

A new species of *Bonellia* is described from Northern Tasmania. The female differs markedly from the other Australian species in the form of the nephridium and the dwarf male has no clasper or sucker at the posterior end.

INTRODUCTION

There are no published records of *Bonellia* from Tasmanian waters. Nielsen (1963) summarised the information concerning the Australian species of *Bonellia* to that date. Edmonds (1966) recorded *Bonellia gigas* Nielsen and an undetermined species belonging to that genus from the collections of the Port Philip Survey.

Keys to the Australian genera of Echiuroidea are given by Edmonds (1960 and 1963).

Three species of *Bonellia* are now known from Australia, viz., *Bonellia haswelli* Johnston and Tiegs from Port Jackson, New South Wales; *Bonellia gigas* Nielsen from Flinders and Point Lonsdale, Victoria and the species described hereafter from Northern Tasmania.

To facilitate comparison the following account follows that of Nielsen (1963) as closely as possible. All measurements are given in millimetres from specimens preserved in 10% formalin.

TYPE LOCALITY AND HABITAT

Three specimens were collected from Jacobs Boat Harbour, Northern Tasmania on 31 August 1969 by Jean A. Dartnall. Jacobs Boat Harbour (40° 56′ S, 145° 39′ E) is designated the type locality of the new species. The animals were found at low tide level, on sand under rocks in the gullies of Precambrian quartzite which compose the beach.

TYPE MATERIAL

Holotype: ♀, length of body 73 mm, width of body 22 mm, length of proboscis 63 mm. Tasmanian Museum Reg. No. K224.

Allotype: ♂, T.M. Reg. No. K225.

Other paratypes: ♀, length of body 57 mm, width of body 18 mm, length of proboscis 82 mm. Dissected specimen. T.M. Reg. No. K226.

♀, length of body 34 mm, width of body 15mm, length of proboscis 43 mm. Dissected immature specimen not containing eggs or dwarf males. T.M. Reg. No. K227.

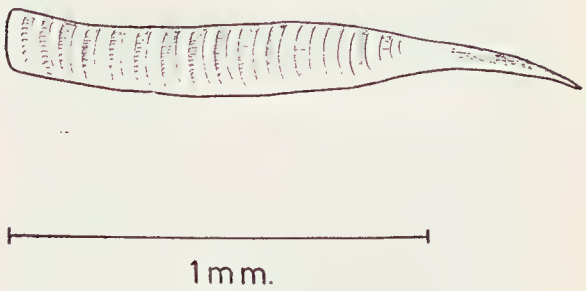

Fig. 1.—*Bonellia tasmanica* n. sp. Cheta of female.

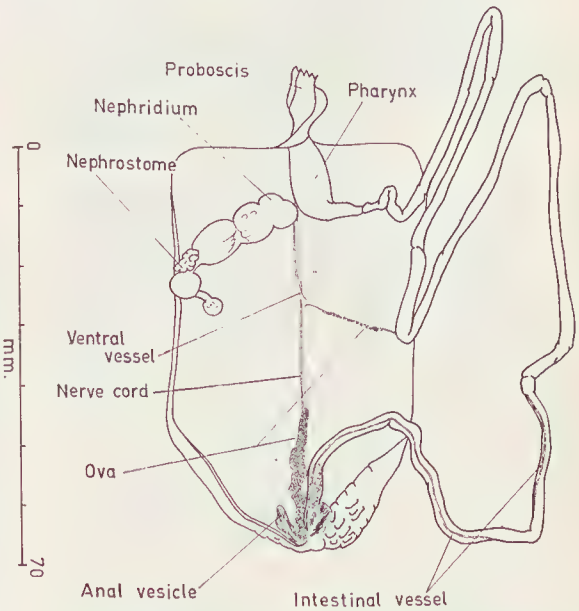

Fig. 2.—*Bonellia tasmanica* n. sp. Female dissected from dorsal side.

Phylum ECHIUROIDEA
Family BONELLIDAE
Genus **BONELLIA** Rolando
Bonellia tasmanica n. sp.

Description of Female

The body of the female is sac-like with a long proboscis, bifurcate at the end. The shape of the living animal is very plastic as it is in almost constant movement.

The epidermis of the body is the deep grey-green usually recorded for these animals. The proboscis is a slightly paler green and the edges of the bifurcated tip are coloured off-white. The epidermis is covered with transverse rows of flattened papillae which are more prominent towards the extremities of the body than on the median portion.

A ciliated groove runs along the dorsal side of the proboscis to the mouth at its base. The anus is surrounded by flattened papillae.

Two chetae project on the ventral side of the animal just posterior to the external opening of the nephridium. The chetae are about 1.3 mm long and have a maximum width of about 0.12 mm (fig. 1). About 0.3 mm of each cheta projects through the skin, the remaining broader portion, which is not flattened, being embedded in muscle. The protruding portion of the cheta is pointed, smooth and highly refractive. The basal portion is encircled by alternating light and dark brown bands. One immature cheta was found embedded in the skin of one specimen near the mature chetae. It was about 0.8 mm in length and identical to the mature chetae in form except that the basal portion was shorter.

The external opening of the nephridium lies just posterior to the chetae. The opening is raised on a small protuberance and surrounded by blunt papillae.

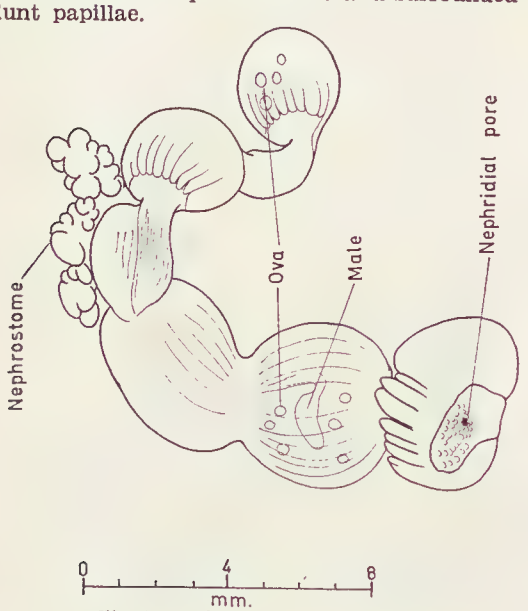

FIG. 3.—*Bonellia tasmanica* n. sp. Nephridium of female from ventral side.

The general anatomy of the female (fig. 2) differs little from that described by Nielsen in *Bonellia gigas*. The mouth opens into a wide pharynx about 13 mm long which leads into a narrow oesophagus about 15 mm long. The oesophagus opens into a thin-walled intestine some 200 mm in length which is coiled within the body and held in place by numerous mesenteric strands which pass from the body wall to the intestine. There is no intestinal siphon and no portion of the intestine is conspicuously coloured.

A pair of anal vesicles arise from the hind gut close to the anus. They are large, thin-walled vesicles into which open about twenty tubules. The tubules then branch three or four times forming a compact mass. Each terminal tubule bears a ciliated funnel at its extremity. The anal vesicles are attached to the body wall by numerous mesenteric strands which also invest the rectal portion of the intestine.

The vascular system consists of a ventral vessel which divides at the pharynx to produce two vessels which run up either side of the proboscis. An intestinal blood vessel, which runs dorsally along the wall of the intestine for about the posterior two-thirds of its length, leaves the gut to join the ventral vessel. The nervous system consists of a pharyngeal ring and a ventral nerve cord.

The ovary is spread along the posterior half of the ventral blood vessel and a few ova were observed spread along the free length of intestinal vessel. The ovary wall is transparent. Pale yellow developing ova can be seen through the wall. The body fluid of one specimen contained about forty pale yellow ova.

The segmental organ, nephridium or uterus (fig. 3) is on the left side of the animal and opens to the exterior just left of the ventral vessel through the pore described above. The nephridium is an off-white or transparent sac depending upon the thickness of the muscles of the nephridial wall. It is about 24 mm in length and consists of a number of distended sacs separated by sphincters of muscle from which muscle strands radiate over the surface of the organ especially on the ventral side. The nephrostome, situated about two-thirds of the way from the anterior and, is transparent and strongly crenate. The nephridium posterior to the nephrostome consists of two sacs connected by a thick walled tubule. The anterior sac of the nephridium is heavily muscular and consists of a lobed and a smooth portion. Eggs were noted in the first thin walled sac and within the posterior sac. Dwarf males were taken from the former. A total of seventy-two eggs and two dwarf males were removed from the nephridium of the gravid paratype female (Reg. No. K226). There were no eggs in the nephrostome. The eggs are rounded, between 0.4 and 0.5 mm in diameter and crowded with yolk granules.

Description of Male

The male of *Bonellia tasmanica* n. sp. is some 7 mm in length, about 0.8 mm wide at the anterior end and, at the posterior end, has a distinct, tapered tail about 0.7 mm in length.

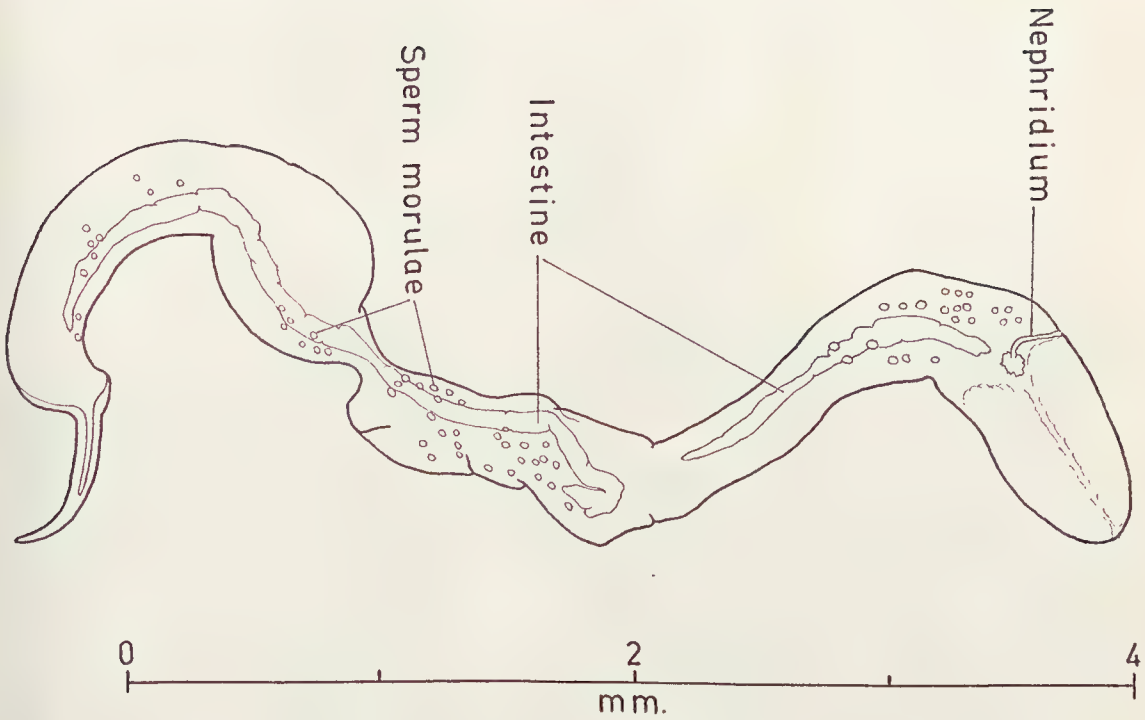

FIG. 4.—*Bonellia tasmanica* n. sp. Male.

The male has no chetae and no clasper or sucker at the posterior end. The general anatomy of the male is illustrated in figure 4.

COMMENTS

The female of *Bonellia tasmanica* n. sp. can be distinguished from that of *Bonellia haswelli* by the absence of an intestinal siphon and from both that species and *Bonellia gigas* by the multisacculate structure of the nephridium.

The male of *B. haswelli* is not known and that of *B. gigas* possesses an anal clasper, a characteristic not shown by the male of *B. tasmanica*.

ACKNOWLEDGMENTS

I wish to acknowledge the help given by Emeritus Professor V. V. Hickman in discussing the taxonomic value of the characteristics observed in this species.

REFERENCES

EDMONDS, S. J., 1960.—Some Australian Echiuroids. *Trans. Roy. Soc. S. Aust.*, 83, 89-98.

————, 1963.—Two new echiuroids from Australia. *Trans. Roy. Soc. S. Aust.*, 87: 243-247.

————, 1966.—Port Philip Survey—Sipunculoidea and Echiuroidea. *Mem. Nat. Mus. Vict.*, 27: 177-178.

JOHNSTON, T. H. & TIEGS, O. W., 1920.—A new species of *Bonellia* from Port Jackson. *Rec. Aust. Mus.* Sydney, 13: 73-76.

NIELSEN, B. J., 1963.—Description of a new species of *Bonellia* from Victoria. *Proc. Roy. Soc. Vic.*, 76 (1): 61-67.

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THE ASTERINID SEA STARS OF TASMANIA

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(With one plate and one table)

SUMMARY

The ten species of sea stars of the family Asterinidae occurring in Tasmania are considered. Synonymies, locality lists and distributional data are given. *Patiriella gunnii* (Gray) is redescribed and lectotypes designated. Some account of characters distinguishing *P. gunnii* and *Patiriella brevispina* H. L. Clark is provided. A key to the species is presented and some account of the zoogeography of the Tasmanian species given, attention being drawn to the existence of pairs of sibling species in the group.

INTRODUCTION

Ten species of three genera of the sea star family Asterinidae are known from the littoral and shallow waters around Tasmania. In this paper abbreviated synonymies are given as necessary and details of localities, habitat and distribution provided. In one case (viz. *Patiriella gunnii* (Gray)) it has been found necessary to redescribe the species. A key to the Asterinidae has been constructed and is presented here. Finally the zoogeography of the Tasmanian asterinids is considered.

Family ASTERINIDAE

Genus **ASTERINA** Nardo, 1834

Asterina atyphoida H. L. Clark, 1916

H. L. Clark, 1916. *Endeavour Rept*, p. 57; pl. 17, figs 1, 2.

Material examined: A total of three specimens.

Localities: Greens Beach, near the mouth of the estuary of the River Tamar.

Habitat: Under rocks and in crevices. Low water to 40 metres, perhaps found at greater depths (Shepherd, 1968).

Distribution: The north coast of Tasmania, Victoria and South Australia.

Asterina inopinata Livingstone, 1933.

A. A. Livingstone, 1933. *Rec. Austr. Mus.* vol. 19, no. 1, p. 3, pl. 5, figs 1-8. 14.

Habitat: Very shallow water (H. L. Clark, 1946).

Distribution: S.E. Australia from New South Wales to Northern Tasmania.

Remarks: No recent material of the species from Tasmania has been seen by this author.

Asterina scobinata Livingstone, 1933

A. A. Livingstone, 1933. *Rec. Austr. Mus.* vol. 19, no. 1, p. 1, pl. 5, figs 9-12. 15.

Material examined: A total of twenty-four specimens.

Localities: Boat Harbour; Greens Beach; Cape Portland; Maria Island; Dunalley; Eaglehawk Neck; Carlton; Blackmans Bay, Kingston; Variety Bay; Bruny Island; Bond Bay, Port Davey.

Habitat: Under rocks and crevices in the lower littoral zone.

Distribution: Tasmania and Victoria. Extension of the known range to Victoria has been reported in another place (Dartnall, in press).

Genus **PATIRIELLA** Verrill, 1913

'regularis' group

Patiriella regularis (Verrill, 1867)

Restricted synonymy

Asterina regularis Verrill, 1867. *Trans. Conn. Acad.*, vol. 1, p. 250.

Patiriella regularis Verrill, 1913. *Amer. Jour. Sci.*, ser. 4, vol. 35, p. 480.

Patiriella mimica Livingstone, 1933. *Rec. Austr. Mus.* Sydney vol. 19.

Asterina regularis Fell, 1959. *Tuatara*, vol. 7, (3), p. 127-142.

Patiriella regularis Dartnall, 1969. *Proc. Roy. Soc. Tasm.* vol. 103, p. 54.

Material examined: A total of 420 specimens.

Localities: Oyster Cove, Kettering; Coningham; Margate; Blackmans Bay, Kingston; Tinderbox; Taroona; Sandy Bay, Hobart; Wrest Point, Hobart; Hobart wharves; Ralphs Bay; Roches Beach; Midway Point; Slopen Main; Variety Bay, Bruny Island.

Habitat: From the mid-littoral to 15 metres on rock, sand and mud.

Distribution: New Zealand and S.E. Tasmania (Dartnall, 1969).

Remarks: Evidence demonstrating that this species may have been imported into Tasmania

with cargoes of commercial oysters was presented in a previous paper (Dartnall, 1969). In the same paper it was suggested that *Patiriella mimica* (Livingstone) is a synonym of *Patiriella regularis*.

Patiriella calcar (Lamarck, 1816)

Restricted synonymy

Asterias calcar Lamarck, 1816. *Anim. sans Vert.*, vol. 2, p. 557.

Asterina calcar Gray, 1840. *Ann. Mag. Nat. Hist.*, vol. 6, p. 290.

Patiriella calcar Verrill, 1913. *Amer. Jour. Sci.*, ser. 4, vol. 35, p. 484; H. L. Clark, 1946. *Carnegie Institution of Washington. Publication* 566, p. 134.

Material examined: A total of 199 specimens.

Localities: Trial Harbour; Granville Harbour; Boat Harbour; Wynyard; Cape Portland; Flinders Island; Bay of Fires; Binnalong Bay; 2 miles north of Scamander; Shelly Beach, Orford; Dodges Ferry; Roches Beach; Primrose Sands; Taroona; Coningham; Adventure Bay, Bruny Island; Bond Bay, Port Davey.

Habitat: Mid-littoral to 10 metres. Rocky shores and rock pools.

Distribution: Tasmania, south and east coasts of Australia from South Australia to Queensland.

Remarks: H. L. Clark (1946) employed the absence of suboral spines in this species to distinguish it from other members of the genus. The presence or absence of suboral spines is not a reliable characteristic of Tasmanian material and tends, also, to impute close relationships between *P. calcar* and the six-rayed *'gunnii'* forms.

The distribution of suboral spines in a sample of 199 specimens of Tasmanian *Patiriella calcar* is expressed in Table I.

'exigua' group

Patiriella exigua (Lamarck, 1816)

Restricted synonymy

Asterias exigua Lamarck, 1816. *Anim. sans Vert.*, vol. 2, p. 554.

Asterina exigua Perrier, 1876. *Arch Zool Exp.*, vol. 5, p. 222.

Patiriella exigua Verrill, 1913. *Amer. Jour. Sci.*, ser. 4, vol. 35, p. 484; H. L. Clark, 1946. *Carnegie Institution of Washington. Publication* 566, p. 136.

Material examined: A total of 257 specimens.

Localities: Trial Harbour; Granville Harbour; Marrawah; Rocky Cape; Boat Harbour; Greens Beach, East Sandy Cape; Cape Portland, Swan Island; Flinders Island; Shelly Beach, Orford; Maria Island; Port Arthur; Nubeena; Murdunna; Dunalley; Bellerive; Hobart; Blackmans Bay, Kingston; Coningham; Policemans Point; Simpsons Bay, Bruny Island; Roaring Beach, Port Davey.

Habitat: Upper and mid-littoral zones. Often found associated with the alga *Hormosira banksii*.

Distribution: Tasmania, south and eastern Australia, Lord Howe Island. Said to occur throughout the Indo-Pacific region.

Remarks: This author has now examined material from South Africa and from the New Guinea archipelago. Even though this material has been attributed to *Patiriella exigua* on external morphology some differences are observable. South African material, for instance, appears to attain a larger size than Australian *P. exigua*. More consistent sampling throughout the Indo-Pacific area will be needed to examine the proposition that the species known as *Patiriella exigua* is a polymorphic assemblage of forms.

Patiriella vivipara Dartnall, 1969

Dartnall, 1969. *Proc. Linn. Soc. N.S.W.* **93** (3): 294-196, pl. XXIX

Localities: Roches Beach; Midway Point; Lewisham; Tesselated Pavement; Blowhole, Eaglehawk Neck.

Habitat: Mid-littoral, gently sloping rocky shores.

Distribution: Restricted to S.E. Tasmania.

Remarks: It is suggested that *Patiriella vivipara* is a sibling species to *Patiriella exigua*.

'gunnii' group

Patiriella gunni (Gray, 1840)

Restricted synonymy

Asterina gunnii Gray, 1840. *Ann. Mag. Nat. Hist.*, vol. 6, p. 289.

Patiriella gunnii Verrill, 1913. *Amer. Jour. Sci.*, ser. 4, vol. 35; p. 484; H. L. Clark, 1946. *Carnegie Institution of Washington. Publication* 566, p. 135.

Patiriella gunnii A. M. Clark, 1966. *Mem. Nat. Mus. Vict.*, No. 27, p. 320; Shepherd, 1968. *Rec. S. Aust. Mus.*, vol. 15 (4), p. 747.

The genitive of modern patronymics would give *'gunni'* as the specific name of this species. No evidence has been given of typographical errors, *lapsus calami* or errors of transcription. Thus the rulings concerning customary usage must apply and *'gunnii'* retained (see Article 19 and Summary 8 of Opinions Rendered, Schenk and McMasters, 1936).

Material examined: A total of seventeen Tasmanian specimens.

Localities: Greens Beach; Cape Portland; Maria Island; Primrose Sands; Variety Bay, Bruny Island.

Habitat: Mid- and lower-littoral to 30 metres, under rocks and ledges.

Distribution: The north and east coasts of Tasmania, and the south and east coasts of Australia from Western Australia to New South Wales. Also recorded from Lord Howe Island.

Remarks: Gray's (1840, 1866) description of *'Asterina gunnii'* from material collected by R. C. Gunn in Van Diemens Land was concise and barely informative. Preserved material of *'gunnii'* fascies (i.e., of *Patiriella gunnii* and *Patiriella brevispina* H. L. Clark) has proven difficult to distinguish. Through the offices of Miss A. M. Clark, the Director and Trustees of the British Museum (Natural History) made available to me

specimens, determined by Gray, to redescribe the species.

A single specimen from a group of four from Sandy Bay, Hobart Town and registered in 1840 is designated the lectotype and three specimens from a series collected at George Town, Northern Tasmania and registered in 1849, paralectotypes.

Lectotype: British Museum Reg. No. 40.3.9.-10. Sandy, Bay, Hobart Town (type locality). Presented by R. C. Gunn.

Paralectotypes: Three specimens. British Museum Reg. Nos 49.11.19.-10-14-33. George Town, Tasmania. Presented by R. C. Gunn.

Description of lectotype: Plate I, figs (i) and (ii)—specimen 40.3.9.-10; R = 22 mm; r = 16 mm; r:R = 1:1.37; vh = 6 mm.

A six-rayed, asterinid sea star, markedly flattened, the actinal surface plain and with a very acute marginal angle.

The abactinal surface is paved with imbricating plates of two kinds. Those of the rays, the disc and most of the abactinal intermediate areas are crescentic at their free edge allowing the passage of papulae. The carinal row of papular plates of each ray are doubly notched allowing the passage of two rows of papulae, one on each side of the midline of the ray.

The plates of the interradial, abactinal areas near to the margin are smaller and non-papulate. Small secondary plates are present between the larger papulate plates.

The exposed surfaces of the abactinal plates are crowned with groups of small, blunt, thorny spinelets, some twenty-eight spinelets being present on the larger plates near the centre of the disc and six to eight spinelets on the plates near to the margin.

The madreporite is rounded, channelled and perforate and situated interradially some 3 mm from the centre of the disc. The anus is not visible in the lectotype.

The superomarginal plates are not distinct from the succeeding rows of abactinal plates. The inferomarginal plates form the edge of the body and each carries a fringing group of seven to nine spinelets.

The actinal surface between the ambulacral grooves is paved with imbricate plates. The largest chevron of plates, reaching from the tip of each ray to the mouth plates, carries one spine on each plate. The succeeding three inner chevrons of plates carry one spine on each plate for about the proximal half of their length and the remainder of the actinal intermediate plates two spines except towards the disc margin where some plates may carry three spines.

In the lectotype each adambulacral plate bears a single subambulacral spine and a pair of furrow spines. Furrow spines may be grouped in threes towards the mouth and singly towards the tip of the rays.

Each oral plate bears five oral spines, the innermost being the largest. The lectotype bears no suboral spines. Pedicellariae are absent.

Diagnosis: A flattened, six-rayed species of *Patiriella* closely related to *Patiriella brevispina* H. L. Clark. In Tasmanian material paired subambulacral spines distinguish *P. gunnii* from *P. brevispina* which most often has single subambulacral spines. A discussion of specific characteristics is given in a following section of this account.

Patiriella brevispina H. L. Clark, 1938

H. L. Clark, 1938. *Mem. Mus. Comp. Zool.*, vol. 55, p. 166, pl. 22, figs 2, 3

Material examined: A total of twelve Tasmanian specimens.

Localities: Burnie; Greens Beach; Cape Portland; Flinders Island.

Habitat: Mid- and lower-littoral to 10 metres on a rock substrate. Most often found under rocks.

Distribution: The north coast of Tasmania and the coasts of Western Australia, South Australia, Victoria, New South Wales and Southern Queensland.

Remarks: *Patiriella gunnii* and *Patiriella brevispina* have long been considered distinct forms by many Australian workers. H. L. Clark (1938, 1946) and A. M. Clark (1966) have both commented upon the validity of *P. brevispina*. A. M. Clark's comments and the brief description of *P. gunnii* offered by Gray (1840 and 1866) prompted an investigation into the characteristics of the material showing the six-rayed '*gunnii*' fascies.

Including the lectotype of *Patiriella gunnii* 250 specimens were available for study and the following characteristics were considered reliable enough to distinguish between the species:—

(1) *Size and shape*: *P. brevispina* may attain a size of 52 mm R as opposed to about 39 mm R in *P. gunnii*. *P. gunnii* is more flattened than *P. brevispina*. The range of vh:R for the two species was 0.21-0.26:1 in *P. gunnii* and 0.35-0.57:1 in *P. brevispina*, i.e., the latter is a more arched form.

(2) *Furrow spinulation*: *P. gunnii* carries more furrow spines on more adambulacral plates than *P. brevispina*.

(3) *Subambulacral spinulation*: *P. gunnii*, notwithstanding the description of the lectotype, most often carries paired subambulacral spines whilst the subambulacral spines of *P. brevispina* are most often monacanthid.

(4) *Colour when alive*: In life *Patiriella brevispina* is consistent in its rich purple colouration on both surfaces of the body and never possesses the mottled and varied colours of *Patiriella gunni*. The tube feet are pale straw coloured in *P. gunnii* and bright orange in *P. brevispina*.

Examination of a series of specimens from Western Australia suggests that intermediate or hybrid forms probably exist on the south-western seaboard of Australia and until more material is available the characteristics recorded here can only be applied to *Patiriella gunnii* and *Patiriella brevispina* from the Maugean Province of Australia.

KEY TO THE TASMANIAN ASTERINIDAE

1.	Abactinal surface clearly divided into two areas: one on the disc and along the crests of the rays of crescentic plates; and other, comprising the rest of the upper surface covered by close set, small, rounded plates	Genus **PARANEPANTHIA** Tasmanian Species *P. grandis* H. L. Clark
	Abactinal surface not clearly divided into two areas	(2)
2.	Carinal abactinal row of plates doubly notched for papulae	Genus **PATIRIELLA**
	Carinal abactinal row of plates with a single papular notch or none	Genus **ASTERINA** (8)
3.	Rays normally five in number	(4)
	Rays normally more than five	(6)
4.	Large, >15 mm. Gonoduct directed aborally	*Patiriella regularis* (Verrill)
	Small, R<15 mm. Gonoduct directed orally or absent	(5)
5.	Gonoduct absent; coelomic incubation of young. Actinal surface orange yellow	*Patiriella vivipara* Dartnall
	Gonoduct directed orally. No internal incubation. Actinal surface blue-green	*Patiriella exigua* (Lamarck)
6.	Rays six; actinal intermediate spines paired	(7)
	Rays seven to eleven, usually eight; actinal intermediate spines single	*Patiriella calcar* (Lamarck)
7.	Flattened; subambulacral spines usually diplacanthid. Colour varied	*Patiriella gunnii* (Gray)
	Arched; subambulacral spines usually monacanthid. Colour in life consistently deep purple	*Patiriella calcar* H. L. Clark
8.	Form stellate	*Asterina scobinata* Livingstone
	Form pentagonal, though margins may be concave	(9)
9.	Actinal intermediate plates with single spine or none	*Asterina atyphoida* H. L. Clark
	Actinal intermediate plates with fine spines in groups of two to four	*Asterina inopinata* Livingstone

Genus **PARANEPANTHIA** Fischer, 1917

Paranepanthia grandis (H. L. Clark, 1928)

Synonymy

Nepanthia grandis H. L. Clark, 1928. *Rec. S. Aust. Mus.* vol. 3, p. 393, fig. 113.

Paranepanthia grandis H. L. Clark, 1938. *Mem. Mus. Comp. Zool.*, vol. 55, p. 159.

Material examined: A total of four specimens.

Localities: Tasmania; D'Entrecasteaux Channel; Piersons Point, Derwent Estuary.

Habitat: All the Tasmanian material was collected between 4 and 6 fathoms. Shepherd (1968) gives the vertical range of this species as between 2 and 40 metres in South Australia.

Distribution: West Australia to Sydney Harbour and southwards to Tasmania.

ZOOGEOGRAPHY OF THE TASMANIAN ASTERINID FAUNA

Of the ten species of Tasmanian asterinids one, *Paranepanthia grandis*, cannot be included in any discussion of the zoogeography of the family. The material available only reflects localised collecting and although that species may be expected along the eastern and northern coasts of Tasmania discussion must await further evidence.

Patiriella regularis must also be excluded from discussion because evidence has been provided that the species is a recent recruit to the Tasmanian sea star fauna (Dartnall, 1969).

Only one species can be said to be endemic to Tasmania, viz. *Patiriella vivipara*, and only *Patiriella exigua* is distributed outside Australia and comment on the possible status of this form was made earlier in this account.

Two phenomena are of interest—

1. The distributions of *Asterina scobinata*, *Asterina atyphoida* and *Asterina inopinata* mesh in the crossroads of the Bass Strait. The distribution of these species is additional evidence for the south-eastern Australian 'Maugean' marine province as defined by Bennett and Pope (1960) and the overlapping of warm and cool temperate areas also described by these authors.
2. Pairs of sibling species occur whose distribution lies along various radii from the focal point of Bass Strait. These pairs are *Asterina atyphoida/inopinata*, *Asterina burtoni/scobinata*, *Patiriella exigua/vivipara* and *Patiriella gunnii/brevispina*. In two cases, those of *A. scobinata* and *P. vivipara* hermaphrodism occurs and *A. atyphoida* possesses orally directed gonoducts in contrast to *A. inopinata* where the gonoducts are orientated aborally. Thus each form of a species pair is isolated by a reproductive specialisation. It remains to be seen by what mechanism the *Patiriella gunnii/brevispina* species remain distinct, but investigation of the ecology and the temporal sequence of reproduction in the two species may provide a fruitful field of investigation.

The relationships of the Tasmanian asterinid fauna lie with Australia and the Indo-West-Pacific. The '*regularis*' forms of *Patiriella* have been successful in extending their distribution around

the Southern Hemisphere, perhaps by means of the West Wind Drift. The sequence of species eastwards in this case is (*a*) *Patiriella calcar* in Australia, (*b*) *Patiriella nigra* H. L. Clark, Lord Howe Island, (*c*) *Patiriella regularis* and *Patiriella oliveri* (Benham) in New Zealand and (*d*) *Patiriella calcarata* (Perrier) from the Juan Fernandez Islands and possibly the eastern coasts of South America. This author does not accept that Perrier's *Patiriella fimbriata* belongs to that genus and that form is not included here.

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REFERENCES

BENNETT, I. & POPE, E. C., 1960.—Intertidal Zonation of the Exposed Rocky Shores of Tasmania and its Relationship with the Rest of Australia. *Aust. J. Mar. Freshw. Res.*, 11, pp. 182-219.

CLARK, A. M., 1966.—The Port Philip Survey 1957-63. Echinodermata. *Mem. Nat. Mus. Vic.*, 27, pp. 289-384.

CLARK, H. L., 1938.—Echinoderms from Australia. *Mem. Mus. Comp. Zool., Harvard*, 55, pp. 1-596.

————, 1946.—The Echinoderm Fauna of Australia, its composition and its origin. *Publ. Carnegie Instn.*, No. 566, 567 pp.

DARTNALL, A. J., 1969.—New Zealand Sea Stars in Tasmania. *Proc. Roy. Soc. Tasm.*, 103, pp. 53-55.

————, (in press).—Some species of *Asterina* from Flinders, Victoria. *Victorian Naturalist.*

GRAY, J. E., 1840.—A Synopsis of the Genera and Species of the Class Hypostoma (*Asterias* Linnaeus). *Ann. Mag. Nat. Hist.*, 6, pp. 175-184, 275-290.

————, 1866.—Synopsis of the Species of Starfish in the British Museum (with figures of some of the species). iv + 17 pp., 16 pls. (London).

SCHENK, E., & MCMASTERS, J., 1936.—*Procedure in Taxonomy.* Stanford University Press.

SHEPHERD, S. A., 1968.—The Shallow Water Echinoderm Fauna of South Australia. I. The Asteroids. *Rec. S. Aust. Mus.*, 15, (4), pp. 729-756.

TABLE I

Distribution of suboral spines in a sample of 199 specimens of *Patiriella calcar* from Tasmania.

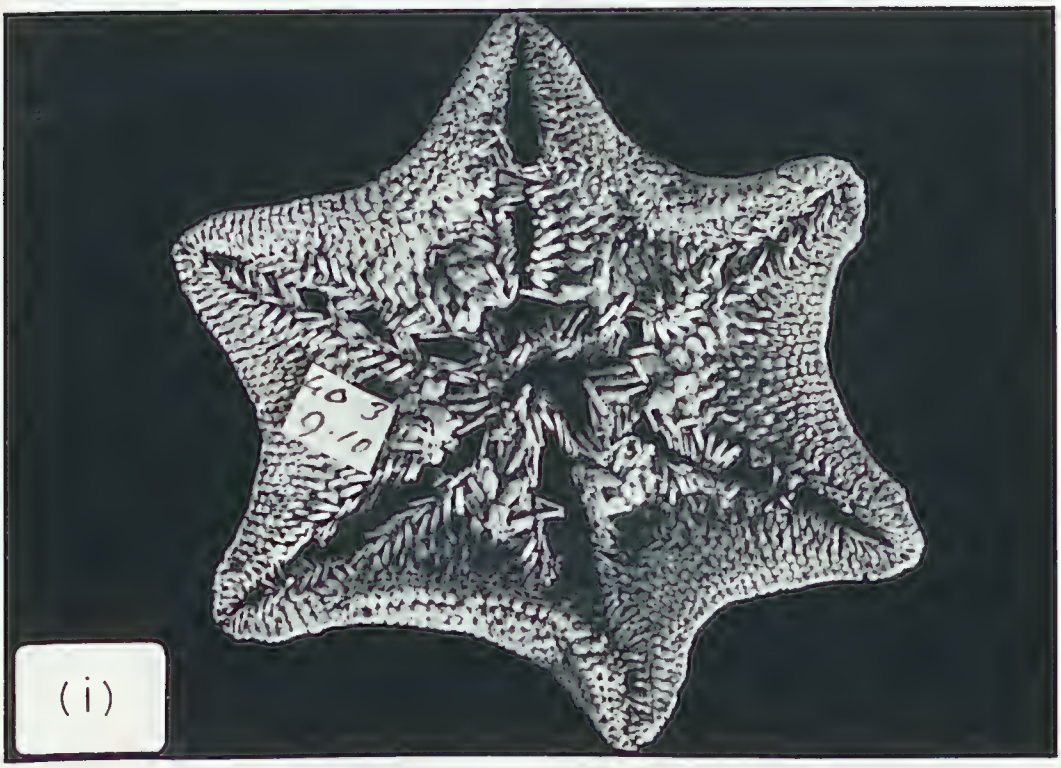
(*a*)

Number of Rays	Number of Specimens	Number of oral plates 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
8	56	6	7		2	2	4	5	2	1	2	2	4		3	4	12						
9	6				1	1			1								1		2				
10	3	1	2																				
11	1				1																		
Total ..	66	Number of specimens carrying single suboral spines																					

(*b*)

Number of Rays	Number of Specimens	Number of oral plates 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
8	8	1	2	2	3																		
10	1		1																				
Total ..	9	Number of specimens carrying paired suboral spines																					

Total number of specimens in sample	199
Number carrying suboral spines	75
Number without suboral spines	124
Number of specimens with one and two suboral spines on some plates ..	9



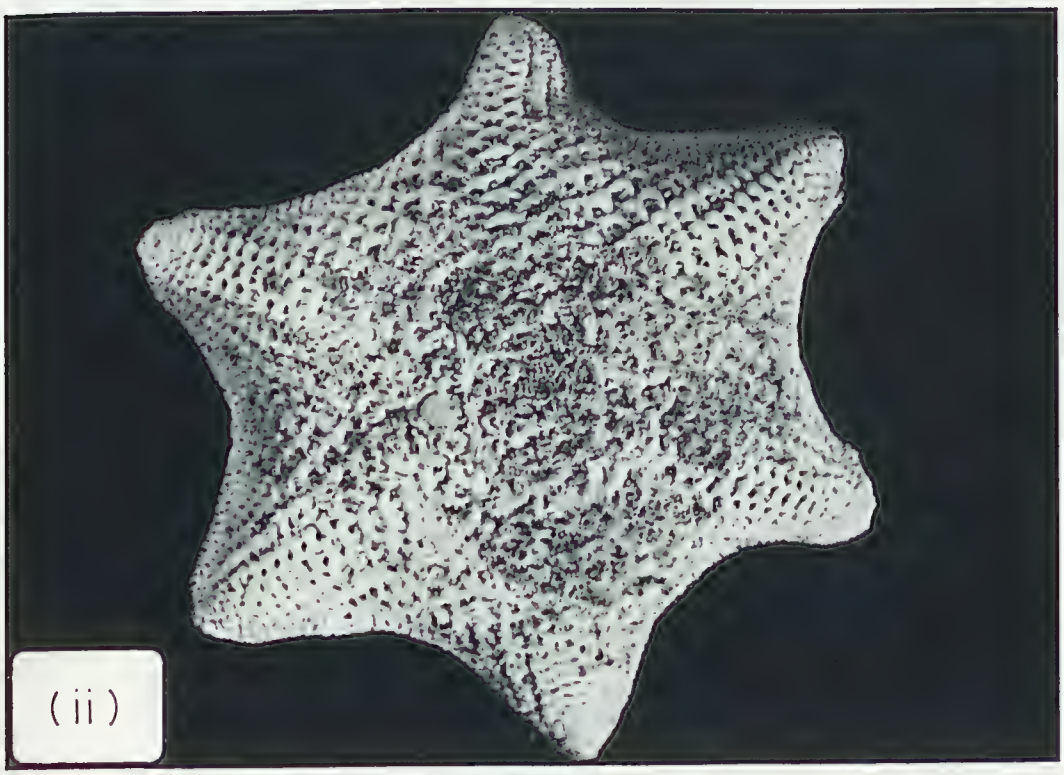


Plate 1.—Lectotype *Patiriella aunuii* (Gray), British Museum (Natural History) register No. 40.3.9.-10. -
(i) Actinal surface.
(ii) Abactinal surface

[*Photographs*: G. G. Harrison

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THE CHROMOSOMES OF SOME TASMANIAN RODENTS

By

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(With six plates and one table)

ABSTRACT

The karyotypes of three species of Tasmanian rodents, *Rattus lutreolus* Grey, 1841 (2n=42), *Pseudomys higginsi* Trouessart, 1897 (2n=48), and *Hydromys chrysogaster* Geoffrey, 1804 (2n=48), are described and illustrated. The most successful preparation method, from bone marrow, is described and the results discussed in the light of other published results.

INTRODUCTION

This paper presents the karyotypes of three species of indigenous Tasmanian rodents, *Rattus lutreolus* Grey, 1841 (2n=42), *Pseudomys higginsi* Trouessart, 1897 (2n=48), and *Hydromys chrysogaster* Geoffrey, 1804 (2n=48).

MATERIAL AND METHODS

All animals were live-trapped in south-east Tasmania. Details of number and sex are shown in the table. Skins and skulls of all specimens, with trapping data, are lodged in the Tasmanian Museum, Hobart, and their museum registration numbers are also shown in the table.

The animals were killed with trichloroethylene and tissues for examination removed immediately after death. The most successful preparations were those from bone marrow. The xiphysternum and about 1-1½ inches of the sternum were removed and placed in 5 cc of Ringer solution, to which 0.5 mg of demecolcine had been added. The tissue was minced in this and then allowed to stand at room temperature for an hour. After centrifuging, the deposit was resuspended in warm 0.075 M potassium chloride and the suspension maintained at 37° C for an hour. Fixation was by methanol and acetic acid in a 3:1 mixture and the preparations were stained in Giemsa.

Various adaptations of methods used for human tissues were used to culture blood, spleen and testicular tissues but none was uniformly successful.

RESULTS

The karyotypes are shown in figures 1-6. The karyotype of *Rattus lutreolus*, with forty-two chromosomes and an XX-XY sex chromosome mechanism, closely resembles that of *Rattus rattus*. It has been previously described from one specimen by Kennedy (1969).

The karyotype of *Hydromys chrysogaster* has forty-eight chromosomes and confirms that recently reported by Martin (1969). Unlike that author I do not feel able to divide the large group of acrocentrics or to distinguish sex chromosomes. Kennedy (1969) described an identical karyotype from one South Australian specimen of *H. chrysogaster*.

The karyotype of *Pseudomys higginsi* is indistinguishable from that of *H. chrysogaster*.

DISCUSSION

Matthey (1968) has recently commented on the particular interest of cytogenetic studies on Australian rodents because of their unusual evolutionary history. It is, therefore, interesting to note that the karyotype of *Rattus lutreolus* could be a basic one from which those of *Rattus assimilis*, thirty-eight chromosomes, and *Rattus conatus*, thirty-two chromosomes (Martin, 1969) may be derived by a series of Robertsonian translocations. Kennedy (1969) was able to suggest from her own work that the karyotypes of *R. assimilis*, *Rattus fascipes* and *Rattus greyii* could be derived from the *R. lutreolus* karyotype.

The karyotypes presented here would suggest that *Pseudomys* and *Hydromys* are closely related genera although they are morphologically very dissimilar and have been placed by Simpson (1961) in separate groups. The karyotype of *P. higginsi* differs from that described from one specimen of *Pseudomys minnie* by Kennedy (1969). *P. higginsi* has no submetacentrics whereas Kennedy describes *P. minnie* as having two pairs. Hence, using Matthey's concept of total metaphase arm number, there is a difference of eight arms between these species.

This difference and the possibility of creating a possible sequence for the evolution of the *Rattus* species based on translocations, suggest that some revision of the taxonomy of this group may be necessary when karyotypes of more species are known.

ACKNOWLEDGMENTS

I would like to thank the Kingston Beach Golf Club for permission to trap on its land, and the Tasmanian Museum, the Zoology Department of the University of Tasmania and Mrs J. Lasky for the loan of traps.

References

KENNEDY, J. A., 1969.—The karyotypes of some Australian rodents (Rodentia: Muridae). *Aust. J. Zool.*, 17, pp. 465-471.

MARTIN, J. H. D., 1969.—Chromosomes of some native Muridae in Queensland. *Queensland Journal of Agricultural and Animal Sciences*, 26, pp. 125-141.

MATTHEY, R., 1968.—Les chromosomes de *Leggadina hermannsburgensis hermannsburgensis* Waite, et le problème des Muridae australiens. *Experientia*, 24, pp. 1160-1161.

SIMPSON, G. G., 1961.—Historical zoogeography of Australian mammals. *Evolution*, 15, pp. 431-446.

TABLE

Species	*Sex*	*Chromosomes examined from*	*Tasmanian Museum Number*
Rattus lutreolus	Female	Blood and spleen	A849
Rattus lutreolus	Female	Bone marrow	A852
Rattus lutreolus	Female	Bone marrow	A850
Rattus lutreolus	Male	Bone marrow and spleen	A848
Rattus lutreolus	Male	Bone marrow	A851
Pseudomys higginsi	Female	Bone marrow	A846
Pseudomys higginsi	Female	Bone marrow	A847
Pseudomys higginsi	Male	Bone marrow	A845
Pseudomys higginsi	Male	Bone marrow and testis	A841
Hydromys chrysogaster	Female	Bone marrow	A843
Hydromys chrysogaster	Male	Bone marrow	A839
Hydromys chrysogaster	Female	Bone marrow	A858

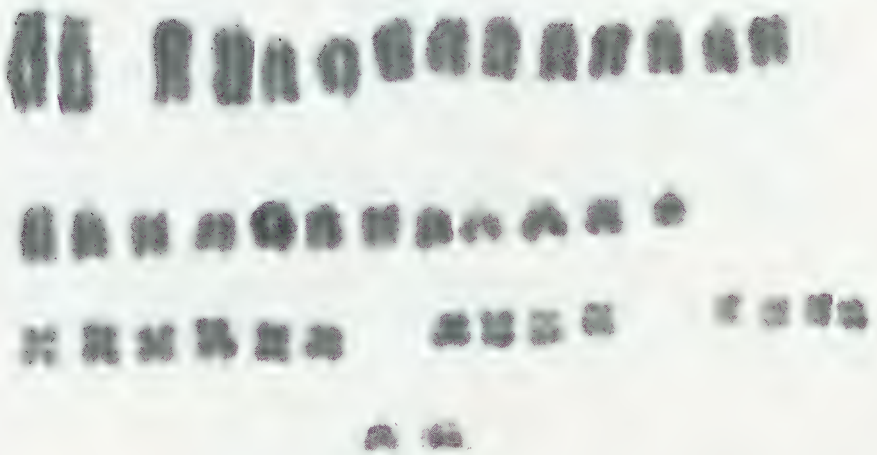

Plate 1.—Karyotype of *Rattus lutreolus*, female. The sex chromosomes are included in the group of acrocentrics.

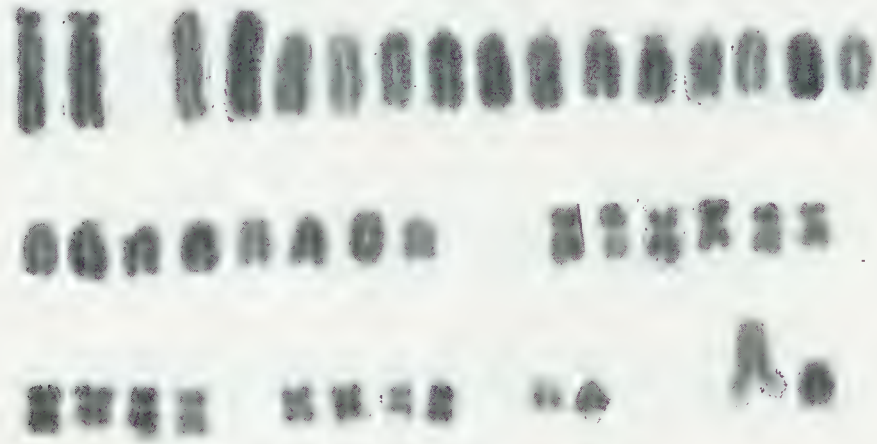

Plate 2.—Karyotype of *Rattus lutreolus*, male. The probable sex chromosomes are at the lower right.

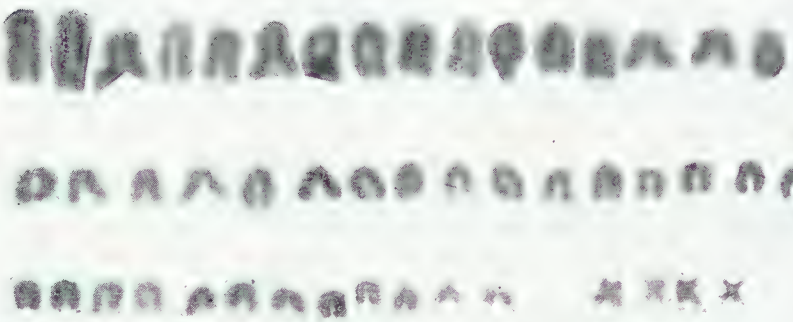

Plate 3.—Karyotype of *Pseudomys higginsi*, female.

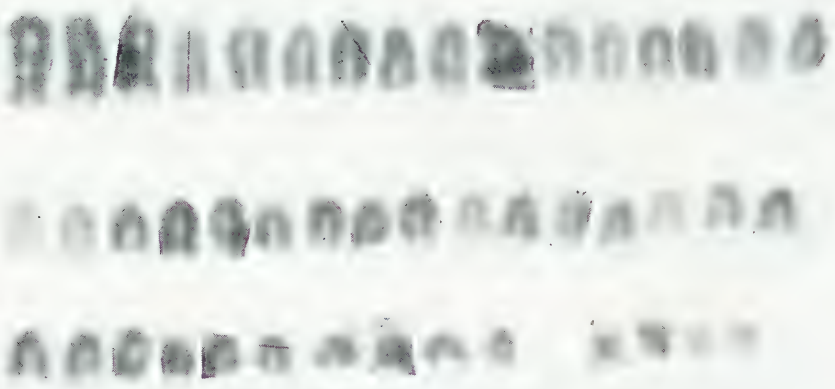

Plate 4.—Karyotype of *Pseudomys higginsi*, male.

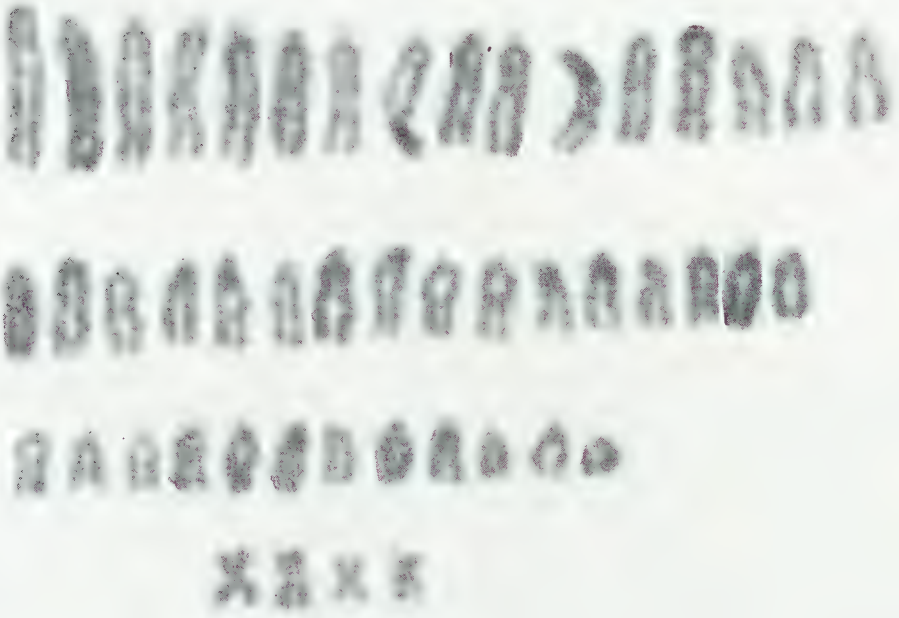

Plate 5.—Karyotype of *Hydromys chrysogaster*, female.

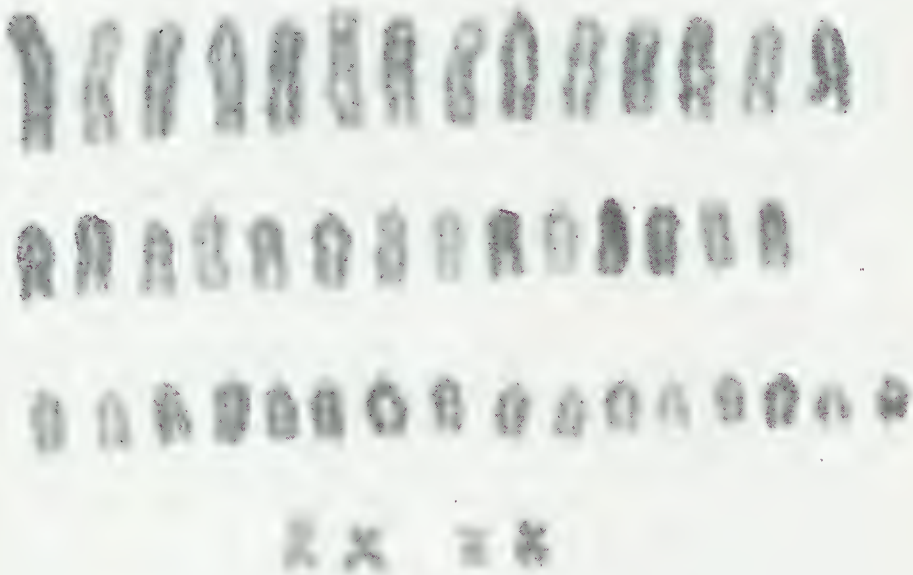

Plate 6.—Karotype of *Hydromys chrysogaster*, male.

[*Manuscript received 1 August 1969*

THE GENUS STIPA (L.) IN TASMANIA

Part I—Introduction and Identification

By

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(With five text figures and one plate)

ABSTRACT

This paper is the first of a series concerned with the revision of the genus *Stipa* in Tasmania. Criteria allowing a new approach to identification at the specific level, both in the herbarium and in the field, are described by means of a detailed study of patterns of hook and hair ornamentations found on the adaxial surface of leaf blades. Nine ornamentation patterns are illustrated in conjunction with their associated spikelet forms. *Stipa pubescens* R.Br. var *aphylla* Rodway is raised to specific rank and an amended descriptions is presented.

INTRODUCTION

The genus *Stipa* commonly called Speargrass is part of the tribe Stipeae (Hubbard in Hutchinson, 1959; Elias, 1942, 47-50) which also includes *Aristida* (the three-awned speargrasses occurring on the mainland of Australia), *Nassella* (the species *N. trichotoma* (Nees) Hack. Serrated Tussock occurring as a dangerous noxious weed in S Tasmania and introduced from New Zealand), *Oryzopsis* (represented in Tasmania by *O. miliacea* (L.) Benth. Rice Millet), and *Piptochaetium* a South American genus.

The world distribution of *Stipa* includes besides Australia and New Zealand, Russia, N and S America, Spain and Portugal, N Africa, and one native species occurs in S Africa (*S. dregeana* Steud.). Stapf (in Hughes, 1921) suggested that the Australian species are more or less unrelated to those from other world areas, and more recent studies on N American species (Hitchcock, 1950) and S American species (Matthei, 1965; Caro, 1966) confirm his view for America at least. Although *S. teretifolia*, a native Australian species, does occur naturally in the North Island of New Zealand (Cheeseman, 1906), on morphological and ecological grounds it would appear to be in a category of its own.

The genus in Tasmania is mainly distributed in dry sclerophyll and open or cleared areas with under 40 inches annual rainfall, largely below 1,500 feet altitude.

The earliest recorded specimens of *Stipa* in Tasmania and indeed in Australia generally are to be found amongst the collections of Labillardière (Labillardière, 1804) and Robert Brown (Brown, 1835), who deposited their material including many type specimens in herbaria outside of Australia, in Brown's case mostly at the British Museum and at the Royal Herbarium, Kew. The resulting difficulty of obtaining the type material for study in Australia has added to the problem of distinguishing between the superficially similar specific entities existing here. Major contributions to herbarium collections were later made by William Gunn in the 1840s, L. Rodway (ca. 1900), Dr W. Curtis (from 1940-), Dr N. Burbidge in 1949, and Drs M. E. Phillips and J. W. Vickery in 1962. Hughes (1921, 1922) has provided the main basis for work on the genus since the 1920s, and the only records of Tasmanian species of *Stipa* since then are available in Willis (1962) and Townrow (1969). Miss Hughes was much handicapped in her revision as the specimens she had to work on were often incomplete, immature, and of insufficient variety to give a true picture of the range of living plants within each entity.

The difficulty of sorting out entities is still acute, and the present paper is a portion of a larger programme of study concerned with the revision of the genus *Stipa* in Tasmania. A new approach to identification of related entities at the specific level is presented based on patterns of ornamentation of adaxial leaf surfaces. The method developed can be applied with equal facility in the field or in the herbarium, on fresh or dried material, with or without mature inflorescences.

CRITERIA

Hughes' (1921) taxonomic criteria are primarily:—

1. the length of the palea (valvule) relative to the lemma (valve);
2. possession of lemma lobes;
3. presence or absence of leaf blades;
4. longevity of plant—perennial or annual;
5. awn characters—
   the shape of the bristle,
   the hair ornament of the awn;

6. prominence of glume veins;
7. glume bulging in conjunction with turgidity of the floret,

and secondly:—

1. hairiness of panicle branches;
2. density and colour of lemma hairs;
3. glume length;
4. leafblades rough or smooth, hard or soft;
5. ligule length;
6. plants stout or slender;
7. awn length;
8. leaf sheath villous or glabrous.

These criteria were satisfactory when applied to the restricted range of material Miss Hughes worked with, but are much less so when applied to the larger more representative collections of material now increasingly available. Many species within the genus are superficially similar, and the living specimen in situ presents a very different appearance from the dried herbarium specimen. The unsatisfactory nature of the use of the earlier taxonomic criteria is demonstrated by:—

1. *Habit*: Only a few culms from any sizeable specimen will be preserved and these will give no real idea of the appearance of the living plant in the field. The size of clump, and height and robustness of a species of speargrass is in any event a variable feature.

2. *Leaves*: The true width of the blade varies up the culm and is obscured by rolling in dry conditions. The character of the ligule is variable but is useful in some cases, e.g., *S. pubescens* where it is finger-nail shaped, compared with *S. nervosa* where it is truncate with a ciliate margin. I suspect the lop-sided appearance of the ligule found in some specimens to be an indication of hybrid origin. The presence of hairs round the back of the leaf at the junction of blade and sheath ('collar') is variable in those species showing this feature. The density of hairs when present in this position, may be modified by exposure to abrasion, the hairs being easily rubbed off in windy situations.

3. *Inflorescence*: Some species in still air exhibit a characteristically-shaped inflorescence, e.g., *S. pubescens* is lop-sided, *S. nervosa* is more regularly pyramidal. This feature is almost completely obscured in herbarium specimens and rarely recorded on the label. The shape of the inflorescence also varies with its state of maturity and unless known from first emergence to senescence is an unreliable taxonomic feature.

4. *Glumes*: The glumes have hyaline fragile tips which tear off very easily, so that measurements of length are virtually useless unless made on completely undamaged specimens, a condition rarely found in herbarium material or in field situations. An apparent gaping of glumes which may not be present naturally is often produced during the pressing of specimens. Prominence of veining, although rightly emphasised by Hughes (1921), I find a character difficult to apply as it is frequently obscured by environmental bleaching or overpigmentation.

5. *Lemmas*: Hair ornament on the lemma body and awn is a widely-used character in identification. A true appreciation of hair-distribution, -length and -colour is possible only when based on a dry lemma which has been stored for some time. Any remnant of dampness causes hairs to remain appressed to the lemma surface. Awns develop characteristic curves or bends only when dry. Length of the bristle is unreliable because of its fragile nature. Maximum 'bulge', size, and colour of the lemma body are fully developed *only by lemmas containing a ripening caryopsis*. Inflorescences produced early or very late in the season produce very little if any fertile seed, and the lemmas remain pale-coloured and shorter and thinner. This has given rise to much confusion in identification. Lemma lobes (outgrowths from the top margins of the lemma at the awn base) are of minor assistance in Tasmanian identifications, the only species with lemma lobes visible to the naked eye being *S. teretifolia*. In the other species these structures are minute and variable both in presence and dimension.

6. *Leaf blade cross sections* are useful but difficult to interpret in practice, and other criteria are easier to use.

I have found that most of the Tasmanian speargrasses fall into nine major populations showing fairly wide variation within each. I also suspect that hybrid swarms occur between these populations which further complicate the situation, these being intermediate in all external features.

Further criteria were sought and are presented here.

A. Criteria for use in the herbarium:—
   1. Adaxial leaf surface ornamentation.
   2. Lemma characters.

B. Criteria for use in the field:—
   1. Adaxial leaf surface ornamentation.
   2. Lemma characters.
   3. Shape of inflorescence.
   4. Habitat.

A. In the Herbarium

1. *Adaxial Leaf Surface Ornamentation*: This consists of various arrangements of hooks, hairs, or tubercles borne on the upper surfaces of the leaf-blade ribs (figs 1, 2, plate 1). The following criteria are suggested:—

(*a*) Ornament.—Absence or presence of hooks, hairs or tubercles alone or in combination.

(*b*) Hairs.—Length, density, diameter, direction in which hairs are borne relative to the long axis of the blade, presence of swollen basal portion.

(*c*) Hooks.—Length, density, and direction of hook-tip relative to the long axis of the blade.

Actual measurements of length of hairs and hooks are not as helpful as are visual comparisons made between the major patterns described (figs 1, 2).

2. *Lemma Characters*: Bearing in mind the difficulties already noted, the characters used traditionally are satisfactory if the lemma studied contains a developing caryopsis and has been

stored dry for some weeks. The following criteria are suggested (figs 3, 4, 5):—

(*a*) Hair ornamentation.—Length, density, direction and colour of the hairs on the body, crown, callus and awn (bristle and column).

(*b*) Body.—Shape, dimensions (including callus in length measurement), colour as distinct from hair colour, surface sculpturing.

(*c*) Callus—

Scar.—The abscission scar on the lower surface of the sharp naked tip of the rachilla joint which is shed with the lemma shows variations in length, overall shape, and in the shape of the groove or trough down its adaxial surface. Groups of apparently closely related species have characteristically shaped callus-scars (see figs 3, 4, 5—*Stipa compacta, S. stuposa, S. semibarbata* and *S. mollis* compared with *S. teretifolia* or *S. variabilis*).

Hairtuft.—The densely hairy rachilla section between the lemma-base and the callus-scar varies in length and hair character according to the species.

(*d*) Awn.—Diameter of the column, if bent or curved when dry, number of times bent, length of column to the first bend.

(*e*) Lemma lobes.—Presence or absence, length, ornamentation.

N.B.: It is highly desirable to make accurate records of colour by means of the Munsell Color Chart system (Munsell, 1954).

The lemma characters of the nine Tasmanian species described are shown in Table 1.

B. Criteria for Use in the Field

1. *Adaxial Leaf Surface Ornamentation*: The appearance of the adaxial leaf surface at ca. x 15 (i.e., in the field) is highly characteristic for the species. But it is not the same as the appearance at x 40. Moreover, the lower power appearance is virtually impossible to describe or figure adequately even by photographs. Probably the best thing is for the investigator to devise his own terms, after examination and identification of his material, first at x 40, then at a lower magnification.

2. *Lemma Characters*:

(*a*) Hairs.—The distribution and length of hairs may be discernible if the lemma is mature and the air is dry. Distribution and length of the hairs on the awn is useful in distinguishing between *Stipa mollis* and *Stipa semibarbata* (fig. 3). The presence of a crown of longer hairs at the top of the lemma and the base of the awn is useful in separating *S. stuposa* and *S. compacta* from the other Tasmanian species (figs 3, 5), while the actual length of the crown hairs helps to distinguish between both immature and mature specimens of these two species.

(*b*) Dimensions of mature lemma body + callus.—The length of the lemma body can be used to distinguish some species from the rest, the shortest belonging to *S. variabilis* and the longest being found in *S. aphylla, S. pubescens, S. stuposa* and *S. teretifolia* (figs 3, 4, 5).

(*c*) Colour of the viable lemma.—The colour of hairs and body surface combined as seen by the naked eye is useful in some instances, e.g., in the identification of *S. compacta* which has a lemma with a bright coppery tint (Munsell Color dark reddish brown 5 YR 3/4).

3. *Inflorescence Shape*: Observations must be made in still air so that this character is of limited use.

4. *Habitat*: Identification may be assisted by a knowledge of groupings of species characteristic of various habitats, e.g., *S. compacta* and *S. teretifolia* are almost entirely confined to extreme coastal areas.

MATERIALS AND METHODS

(a) Material Examined

Specimens from three sources have been utilised.

1. *Specimens loaned from The Royal Herbarium, Kew.* These were stated to be duplicates of type material:—

Stipa aphanoneura Hughes. Kew No. H3908/67. 1.
Det. D. K. Hughes. Swanport. Coll. Mueller, 1877.

S. compacta Hughes. Kew No. H3908/67. 2. Melb. Uni. Herb.
Det. Ballard. Brighton Beach Victoria. Coll. E. Sonenberg 20.9.29.

S. elatior Hughes. Kew No. H3908/67. 3. Flora W. Aust. Ex Herb. Cecil Andrews.
Det. D. K. Hughes. Claremont near Perth. Coll. 15.9.02.

S. fusca C. E. Hubbard. Kew No. H3908/67. 4.
Det. ? Marino near Adelaide. Coll. J. B. Cleland H.491, 8.10.32.

S. pubescens R.Br. Kew No. H3908/67. 5.
Det. D. K. Hughes. New England Herb. F. Mueller, 1887.

S. pubescens R.Br. Kew No. H3908/67 6. Nat. Herb. N.S.W. No. 16577.
Det. ? Nowra North. Coll. E. F. Constable 8.12.50.

S. setacea R.Br. Kew No. H3908/67. 7. Ex Herb. Australiense CSIRO, Canberra.
Det. N. T. Burbidge. Hunter Valley, N.S.W. Coll. R. Story 6911, 25.11.59.

S. semibarbata R.Br. Kew No. H3908/67. 8.
Det. ? Pinery near Grange. Coll. J. B. Cleland H.487, 1.10.32.

S. stuposa Hughes. Kew No. H3908/67. 9. Herb. Australiense No. 3185, CSIRO, Canberra.
Det. N. T. Burbidge. Risdon, Tasmania. Coll. N. T. Burbidge, 18.1.49.

S. mollis R.Br. Kew No. H3908/67. 10.
Det. ? Blackmans Bay near Hobart. Coll. W. M. Curtis 112, 1.1.47.

S. eremophila Reader. Kew No. H3908/67. 11.
Herb. Hort. Bot. Reg. Kew.
Det. ? Mildura, Victoria. Coll. E. J. Sonenberg, 1937.

S. flavescens Lab. Kew No. H3908/67. 12.
Nat. Herb. N.S.W. No. 43.
Det. ? Belltrees via Scone. Coll. H. L. White, February 1910.

S. variabilis Hughes. Kew No. H3908/67. 13.
Queensland Herb., Brisbane Bot. Gard. Flora of W.A.
Det. ? Moora SW Division. Coll. S. T. Blake 18049, 1.9.47.

2. *Material Collected by the Author*

Over 200 specimens of which about 100 have been cultivated in buckets, have been preserved as herbarium material. These specimens were collected by the author, as part of a genus and species distribution survey, on routes crossing the major ecological areas wherever accessible throughout Tasmania. The routes covered a total distance of over 800 miles, with records taken every ½ mile, and collections were made during the growing seasons (October to late January) of 1966, '67 and '68.

3. *State Collections in Australian Herbaria*

The *Stipa* collections in the State Herbaria in Hobart (H), Adelaide (AD), Adelaide Waite Institute (ADW), Canberra (CANB. CSIRO and CANB. Botanical Gardens), Sydney (NSW) and Melbourne (MELB) have been examined with particular reference to species recorded for Tasmania, and to the criteria of leaf ornamentation and lemma characters suggested above.

(b) Methods of Study and of Illustration

1. *Kew Specimens*

Comparative tables of taxonomic detail were drawn up using observations on every available feature. Photographic records of whole herbarium sheets were made. A detailed study of leaf blade ornamentation of these specimens first revealed the possible significance of this character to the identification of species.

2. *Author's Material*

The specimens collected were sorted on the basis of leaf ornamentation and lemma characters (hairs, lemma lobes and callus). A representative specimen of each of the resulting nine groups of plants was selected from the material held in cultivation, and was used in the mature condition in the production of the drawings and photographs presented (figs 1-5, plate 1).

Seasonal changes in inflorescence and spikelet characters, growth rates and dates of flowering were observed during two years' growth for the material in cultivation.

Leaf surfaces were examined fresh and dry with reflected light using magnifications of up to x 40. The area of leaf surface chosen was the adaxial surface of the blade within 1 cm of the ligule (figs 1, 2 at 0). This is where the ornamentation is most developed and most protected, and it is equally well examinable in fresh and dried material. Adaxial leaf surfaces from a flowering culm of each representative specimen were photographed in order from the base (No. 1) of the culm upwards, using a Leitz binocular microscope with an Ultrapac (epi-illuminator) objective No. UO 4/0 10 modified with a No. 2 funnel stop. The drawings reproduced in figures 1 and 2 were made by tracing over these photographs (plate 1). The glumes and lemmas illustrated and described in figures 3-5 and Table 1 were dry and fully mature. Munsell color determinations were made in natural day-light using the naked eye and also x 20 magnification.

OBSERVATIONS AND CONCLUSIONS

(a) The Identity of Tasmanian Populations of Stipa

Nine discontinuous major populations hereafter referred to as species have so far been distinguished, and their identification is based on comparison with the Kew material listed above, and on material including type specimens examined in the various Australian Herbaria.

The populations may be ascribed to:—

1. *Stipa stuposa* Hughes—is apparently endemic to Tasmania, and abundant throughout its range, mostly along roadsides.
2. *S. semibarbata* R.Br.—is widespread along roadsides.
3. *S. mollis* R.Br.—is less widespread, extending to higher elevations than *S. semibarbata*, and often associated with early settlement sites.
4. *S. pubescens* R.Br.—common, is usually closely associated with more open parts of dry sclerophyll.
5. *S. nervosa* var. *neutralis* J. W. Vickery—often confused with *S. pubescens* in the past, it is associated with more open situations than that species.
6. *S. compacta* Hughes—is closely confined to and common on dune slacks and sandy areas within about a quarter of a mile of the shoreline.
7. *S. pubescens* var. *aphylla* Rodway from now referred to as *S. aphylla* nov. sp. (see Appendix for amended description)—is apparently endemic to Tasmania but with close affinities to the mainland *S. muelleri*, occurring in marginal parts of undisturbed areas of dry sclerophyll.
8. *S. variabilis* complex—the Tasmanian population is largely referable to *S. falcata* Hughes and part to *S. scabra* Lindl., the latter being characterised by retrorse hairs on the lower leaf sheaths. No attempt has been made to distinguish between these two groupings in the distribution survey work, but the leaf ornamentation pattern described here is that of the *S. falcata* section.

9. *S. teretifolia* Steud.—this species appears to be quite separate from the others, and is strictly confined to the strandline of the coast and salt water inlets.

A further very rare species showing similarities to *S. nivicola* J. H. Willis from alpine areas of Victoria and N.S.W., has been collected from the middle slopes of Mt Wellington (N. Burbidge in 1949). Other rare species are suspected to occur.

The following species previously recorded for Tasmania have not been found by the author:—

S. aphanoneura Hughes—the Kew specimen was incomplete and immature but still appeared unlike any Tasmanian material seen by me.

S. eremophila Reader—the TYPE at Melbourne is distince from any Tasmanian material I have examined.

S. elatior Hughes—in Tasmania is not distinct from juvenile forms of *S. compacta*.

S. hemipogon Benth—I have seen authentic specimens from West Australia and can state that this species does not occur in Tasmania.

S. flavescens Lab.—J. H. Willis (1967) suggests that Labillardière made the occasional mistake of writing Capite Van-Diemen (Tasmania) instead of Terra Van-Leuwin (W.A.). This situation very possibly applies to his record of *S. flavescens* (Labillardière, 1804). Certainly this species, as represented by the Kew specimen examined, is distinct from any Tasmanian material I have examined, and its callus-scar which is almost round in outline, is quite unlike those of Tasmanian species.

S. setacea Br.—this record is based on Rodway's data (Rodway, 1903, p. 262). His description would fit *S. falcata* in the *S. variabilis* complex. S. *setacea* has a long hyaline ligule up to 6 mm long like that of *S. teretifolia* and comes from N.S.W. and further west. I suspect that Rodway's specimen was mis-identified, but the specimen he described has no leaves and positive identification is now impossible.

The formal taxonomy of the Tasmanian species of *Stipa* is yet to be investigated fully and will be dealt with in a later publication.

(b) Material Located in Australian Herbaria Other than Hobart

(Not including W.A. and Queensland)

In each of the following groups (1-9) the figured specimen is cited first. These specimens are all in the collection of Department of Agricultural Science, (Univ. Tas.), and duplicates are at Kew. The other specimens cited are indistinguishable from the figured specimen, except for a few which differ in characters known to be unreliable taxonomically.

1. *Stipa aphylla* nov. sp. No. 4B.

S. pubescens var. *aphylla* Rodway. (MELB)
Pipetrack Fern Tree.
Coll. J. E. S. Townrow, 7.3.65.

2. *Stipa compacta* No. 94.

S. elatior Hughes SYNTYPE. West (MELB)
Australia.
Coll. J. Drummond No. 959—is undistinguishable from young Tasmanian specimens of *S. compacta*.

S. compacta Hughes. Tower Hill (MELB)
at Trigpoint.
Det. J. H. Willis, 10.11.63.

S. compacta Hughes No. 96323274. (AD)
Lower Murray River.
Coll. R. Hindmarsh, 10.10.45—lemma hairs pale.

S. elatior Hughes No. 96324005. (AD)
No. 96323236—has both pale and coppery lemmas. (AD)

S. compacta Hughes ADW 28130 Pt (ADW)
Lincoln District.
Coll. R. French—has immature, pale lemmas.

S. elatior Hughes ADW 22056 Dune, (ADW)
Pt Fairy.
Coll. D. E. Symons No. 141, 8.11.59—has pale lemmas,

S. elatior Hughes F. V. Mueller Col- (NSW)
lection 959 W. A. Drummond.
According to J. W. Vickery this matches the type specimen. This specimen is indistinguishable from young Tasmanian *S. compacta*.

S. compacta Hughes—specimens poor (NSW)
but show the typical hooked adaxial blade pattern of *S. compacta*.

3. *Stipa mollis* No. 57.

S. hemipogon Benth. No. 2308 (MELB)
Coll. Muir, 13.10.61—a robust form.

S. mollis R.Br.—at bottom of Folder (MELB)
3 of collection loaned to P. F. Morris.

S. plagiopogon J. M. Black. TRS South (AD)
Aust. 65/2 334, 19.12.41.

S. hemipogon Benth.—specimens (ADW)
indistinguishable from Tasmanian *S. mollis*.

S. semibarbata R.Br. Herb. J. (NSW)
Vickery Loc. Lithgow, 2.1.36.

S. mollis R.Br. Launceston, Tas. (NSW)
Coll. J. B. Cleland, 11.1912.

S. mollis R.Br. Maroubra. (NSW)
Coll. L. A. S. Johnson, 26.10.46.

S. mollis R.Br. Tempe district. (NSW)
Coll. J. Boorman No. K431, 10/1899. According to J. W. Vickery 28.8.38, this specimen resembles the Kew Type.

S. semibarbata R.Br. Sandringham (NSW)
Coll. A. Meebold No. 21579, Nov. 1936. Det J. W. Vickery 26.8.38, formerly labelled *S. mollis*.

S. mollis R.Br. Cressy, Tas. (CANB. CSIRO)
Coll. R. M. Moore, 24.11.48. According to N. T. Burbidge 9.9.54, this specimen checks with Brown material from Port Jackson No. 6205 Kew.

S. semibarbata R.Br. Herb. (CANB. CSIRO)
Aust. 25099. Between Dunalley and Murdunna Tas.

Coll. N. T. Burbidge No. 3218, 20.1.49—this is very close to *S. mollis* as understood by the author.

4. *Stipa nervosa* No. 104.

S. nervosa J. W. Vickery. Christ- (MELB)
mas Hills 25 miles NE of Melbourne.
Coll. H. I. Asten.

S. nervosa J. W. Vickery in Folder (MELB)
5 of collection loaned to P. F. Morris.

S. nervosa var. *neutralis* J. W. Vickery. (NSW)
HOLOTYPE J. W. Vickery No. 8569
Katoomba.
Col. S. T. Blake No. 13915, 22.1.39.

S. nervosa var. *neutralis* J. W. Vickery. (NSW)
Orbost Vic.
Coll. F. Robbins ex. herb. A. C. Beauglehole
No. 7955, 11.37.

S. pubescens R.Br. Herb. (CANB. CSIRO)
Aust. 2935. 6 miles E of Launceston, Tas.
Coll. N. T. Burbidge, 8.1.49.

S. nervosa J. W. Vickery— (CANB. CSIRO)
specimens from lower altitudes agree with
Tasmanian material.

Stipa aff. *pubescens* *R*.Br. (CANB. B.G.)
Mathinna, Tas.
Coll. Phillips and Vickery CBGH No. 1268.

5. *Stipa pubescens* No. 65.

S. pubescens R.Br. (MELB)
Coll. Muir No. 308.

S. pubescens No. 692. (MELB)
Coll. Williamson, 2.5.1899 in Folder 4 of col-
lection loaned to P. F. Morris.

S. pubescens R.Br. Mt Lofty. (ADW)
Coll. F. M. Hilton No. 1170, 23.12.54.

S. pubescens R.Br. Herb. Rodway (NSW)
10578. Pieman R. Bridge, cliffs beside
river. W Coast Tas.
Coll. G. & C. Davis, 7.1.37.

S. pubescens R.Br. 10577. Kingston (NSW)
Beach, Tas. 23-11.35.

S. pubescens R.Br. No. 8565. Eagle- (NSW)
hawk Neck, Tas. J. W. Vickery, 15.1.49.

S. pubescens R.Br. Huonville, (CANB. CSIRO)
Tas.
Coll. D. Martin.

Stipa aff. *pubescens* No. 001267 (CANB. B.G.)
Longley, Tas.
Coll. Phillips & Vickery, 19.1.62.

6. *Stipa semibarbata* No. 61.

S. semibarbata R.Br. (MELB)
Coll. Muir, 1956.

S. semibarbata var. *gracilis* Black. (AD)
TYPE—is represented by some Tasmanian
forms.

S. pubescens R.Br.—almost all the (AD)
specimens so labelled are forms of *S.*
semibarbata R.Br.

S. semibarbata R.Br. ADW 28122. (ADW)

S. semibarbata R.Br. Studley Park, (NSW)
Melb.
Coll. I. B .Muir No. 519, 18.10.58.

S. semibarbata R.Br. Herb. (CANB. CSIRO)
Aust. 15827 3 miles W of Mayanup, W.A.
Coll. N. T. Burbidge No. 2551, 12.9.47.

7. *Stipa stuposa* No. 123.

S. stuposa Hughes. Sandy Bay, (NSW)
Hobart.
Coll. Maiden & Cambage, January 1902.

S. stuposa Hughes. Herb No. (CANB. CSIRO)
25096 Risdon, Tas.
Coll. N. T. Burbidge No. 3185, 18.1.49. Bur-
bidge notes that this specimen matches
Gunn Species No. 1480 New Norfolk.

S. stuposa Hughes. 6 miles (CANB. CSIRO)
E of Launceston, Tas.
Coll. N. T. Burbidge No. 2934.

8. *Stipa teretifolia* No. 6.

S. teretifolia Steud.—all specimens (MELB)
agree with Tasmanian material.

S. teretifolia Steud.—all specimens (ADW)
agree with Tasmanian material.

S. teretifolia Steud.—all (CANB. CSIRO)
specimens agree with Tasmanian material.

S. teretifolia Steud.—Herb. (CANB. CSIRO)
No. 001274. Southport, Tas.
Coll. Phillips & Vickery, 20.1.62.

9. *Stipa variabilis* (≡? *S. falcata* Hughes) No. 33.

S. scabra Lindl. 8 miles NW of (MELB)
Ayers Rock.
Coll. M. Lazarides 6152, 7.9.56.

S. variabilis Hughes—in Folder 2 of (MELB)
collection loaned to P. F. Morris and
labelled *S. falcata* by J. H. Willis.

S. variabilis Hughes. Blacks' col- (AD)
lection labelled *1 'falcata'*.

S. falcata Hughes. Blacks' collection (AD)
with very fine hairy basal leaves.

S. scabra Lindl. ADW 31121. (ADW)

S. falcata Hughes—specimens in col- (NSW)
lection with notes sheath marginally
ciliate, lemma circa 6 mm long'.

The range of Tasmanian material falls between the following two specimens:—

S. scabra Herb. Aust. AR (CANB. CSIRO)
227. 36 miles S of Bourke on Cobar Rd,
N.S.W.

S. scabra (CANB. CSIRO)
Coll. 15.9.45 from Barooga, N.S.W.

(c) Descriptions—Notes to the Figures and Plate

The characters of the leaf ornamentation of the nine species illustrated are:—

Stipa compacta—Coarse hooks ca. 0.05 mm long orientated towards the tip of the blade, becoming progressively slightly finer on successive blades from the base of the culm upwards; up to five blades per culm (fig. 1, plate 1a).

S. stuposa—hooks and hairs. Hooks uneven in length, up to ca. 0.05 mm, retrorse; hairs up to 1 mm long, ca. 0.025 mm diam., shaggy on blade 1 but becoming shorter and sparser on successive blades; three to four blades per culm (fig 1, plate 1b).

S. semibarbata—fine teeth and hairs. Sharp points (teeth) vertical on the rib surfaces ca. 0.01

mm long; hairs up to ca. 0.4 mm long, ca. 0.025 mm diam., mostly directed to leaf tip, becoming shorter and sparser on successive blades; up to four blades per culm (fig. 1, plate 1c).

S. mollis—very dense fine hairs ca. 0.15 mm long and 0.01 mm diam., springing out of the rib surfaces at right angles and mostly curving upwards at their tips, becoming denser and shorter on successive blades; ca. four blades per culm (fig. 1, plate 1d).

S. pubescens—moderately dense fine hairs ca. 0.15 mm long and 0.01 mm diam., strongly ascending, becoming shorter and finer on successive blades; ca. three blades per culm (fig. 2, plate 1e).

S. nervosa—hooks, teeth and coarse hairs. Hooks and teeth sparse, up to ca. 0.05 mm long, mostly vertical; hairs up to ca. 0.6 mm long, finely tapering from swollen bases up to 0.04 mm diam., somewhat ascending; ca. three blades per culm (fig. 2, plate 1f).

S. aphylla—coarse, sparse hairs, and shorter processes ranging from minute teeth or hooks 0.01 mm long to spikey, slightly ascending hairs up to 0.25 mm long, hairs with slightly swollen bases. Ribs 0.05 mm diam., about half to one-third the width of those of the other species; up to four blades per culm which are shed early (fig. 2, plate 1g).

S. variabilis—fine hooks and a few scattered coarse hairs. Hooks ca. 0.025 mm long; orientated towards the tip of the blade; hairs strongly ascending, up to 1 mm long and 0.03 mm diam., usually absent from blades higher up culm; ca. three blades per culm (fig. 2, plate 1h).

S. teretifolia—dense minute tubercles, somewhat ascending, with swollen bases and bluntly pointed tips, up to ca. 0.07 mm long and 0.025 mm at the base; up to four blades per culm (fig. 2, plate 1i).

All the hooks, teeth, hairs and tubercles described are colourless. Some variation within the patterns described above is found, and is usually expressed by different densities of hairs, in relation to hooks.

The characters of the lemmas are tabulated in table 1 (see pages 97-98).

The use of the above criteria has proved highly satisfactory in sorting out individual species both in the field and in the herbarium. The method of identification involving ornamentation patterns is particularly useful in large scale analysis of populations in the field, obviating the necessity for fully mature specimens for reliable identification.

It is possible that the identity of parents of suspected hybrids may be derived from an examination of the changes in hair pattern on the blades up a single culm of a hybrid. There is some indication that the pattern on the lowest blade conforms to one parent while that on the uppermost conforms to the other parent. However this aspect needs further examination.

SUMMARY

1. The unsatisfactory nature of Hughes' criteria (1921) in relation to the identification of larger more recent collections of speargrasses (*Stipa*) is explored. New criteria allowing the identification of populations both in the field and in the herbarium are suggested. These utilise hook and/or hair patterns on adaxial leaf surfaces.

2. The material examined includes an extensive Tasmanian collection made by the author, duplicates from the Royal Herbarium, Kew, and *Stipa* collections held in the herbaria in Victoria, N.S.W., A.C.T. and S.A.

3. The ornamentations on the adaxial surfaces of culm-leaf blades of the nine species most commonly found in Tasmania are described and figured. Lemma characters are also described in detail.

4. *S. pubescens* var. *aphylla* Rodway is redescribed and raised to specific rank.

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REFERENCES

ALLAN, H. H., 1940.—*The Naturalised Flora of New Zealand.* Govt Printer, Wellington.

BROWN, R., 1835.—*Prodromus Florae Novae Holandiae.* 2nd ed. London.

CARO, J. A., 1966.—Las especies de *Stipa* (Gramineae) de la region central Argentina. *Kurtziana* 3: 7-119. f 1-23.

CHEESEMAN, T. F., 1906.—*Manual of the New Zealand Flora.* Govt Printer, Wellington.

ELIAS, M. K., 1942.—Tertiary Prairie grasses and other herbs from the High Plains. *Geol. Soc. Am. Special Papers* 41: 1-155.

HITCHCOCK, A. S., 1950.—*Manual of the grasses of the United States.* 2nd ed. Revised AGNES CHASE. U.S.D.A. Miss. Publ. 200.

HOOKER, J. .D., 1855-60.—The Botany of the Antarctic Voyage of H.M. discovery ships *Erebus* and *Terror* in the years 1839-43 III (1-2), Flora Tasmaniae (1855-60). 2: 109-111. London.

HUBBARD, C. E., 1959 in HUTCHINSON, J., 1959.—*Families of Flowering Plants.* 2nd ed. 2. *Monocots.* Clarendon Press.

HUGHES, D. K., 1921.—A Revision of the Australian Species of *Stipa*. *Kew Bull.* 1921: 1-30.

————, 1922.—Further notes on the Australian Species of *Stipa*. *Kew Bull.* 1, 1922, 15-22.

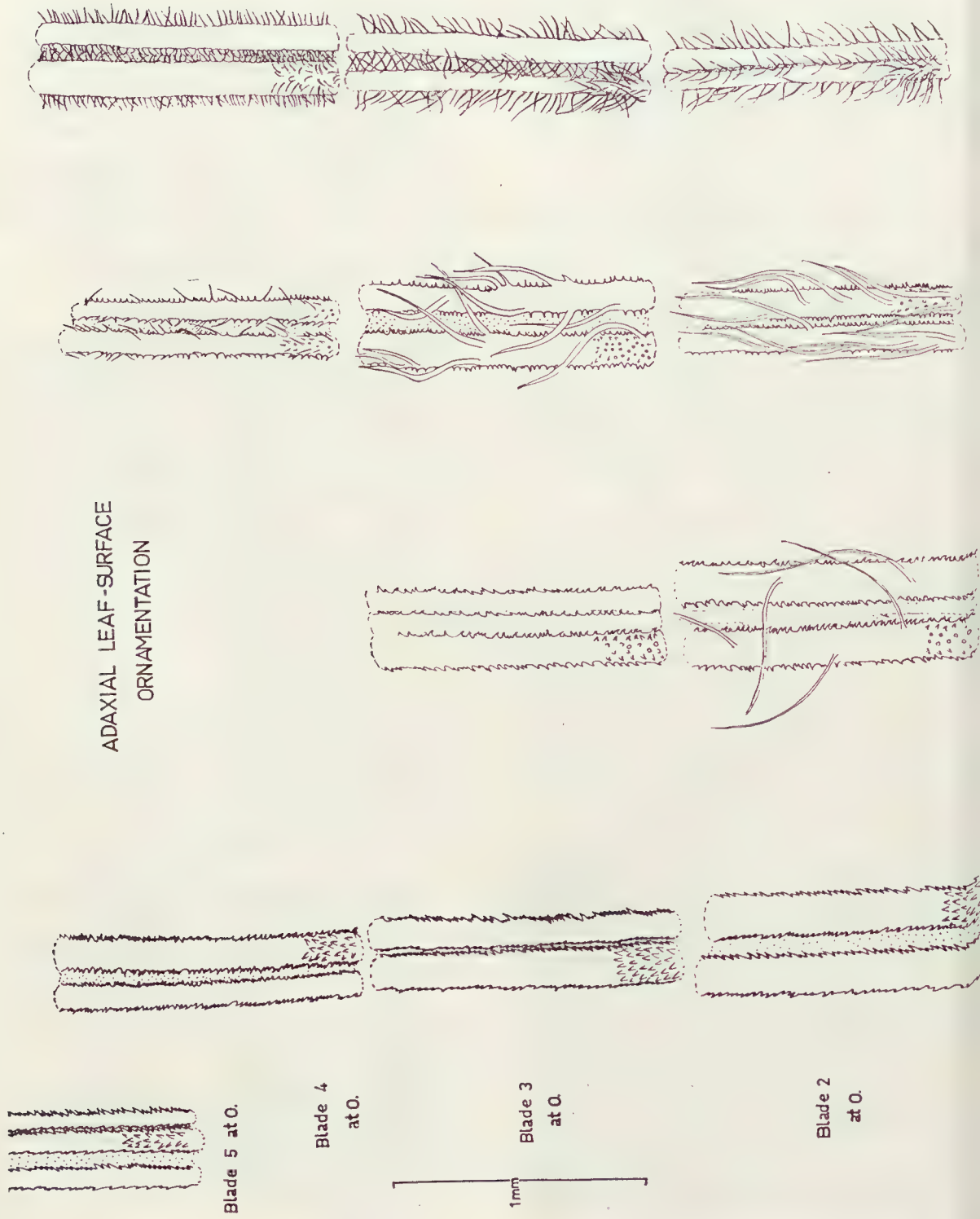
LABILLARDIERE, J. J., 1804.—*Novae Hollandiae Plantarum Specimen.* 1. Paris.

MATTHEI, O. R., 1965.—Estudio critica de las Gramineas del Genero *Stipa* en Chile. *Gayana. Botanica.* 13: 1-136.

MUNSELL COLOR CHARTS: Soil Chart. Hue Range 10 Red-5 Yellow 1954 ed. Munsell Color Co. Inc. Baltimore. U.S.A.

RODWAY, L., 1903.—*The Tasmanian Flora.* Govt Printer, Hobart.

TOWNROW, J. E. S., 1969.—A species list of and Keys to the Grasses in Tasmania. *Pap. Proc. Roy. Soc. Tasm.* 103: 69-96.


ADAXIAL LEAF-SURFACE ORNAMENTATION
Blade 5 at 0.
Blade 4 at 0.
Blade 3 at 0.
Blade 2 at 0.
1mm

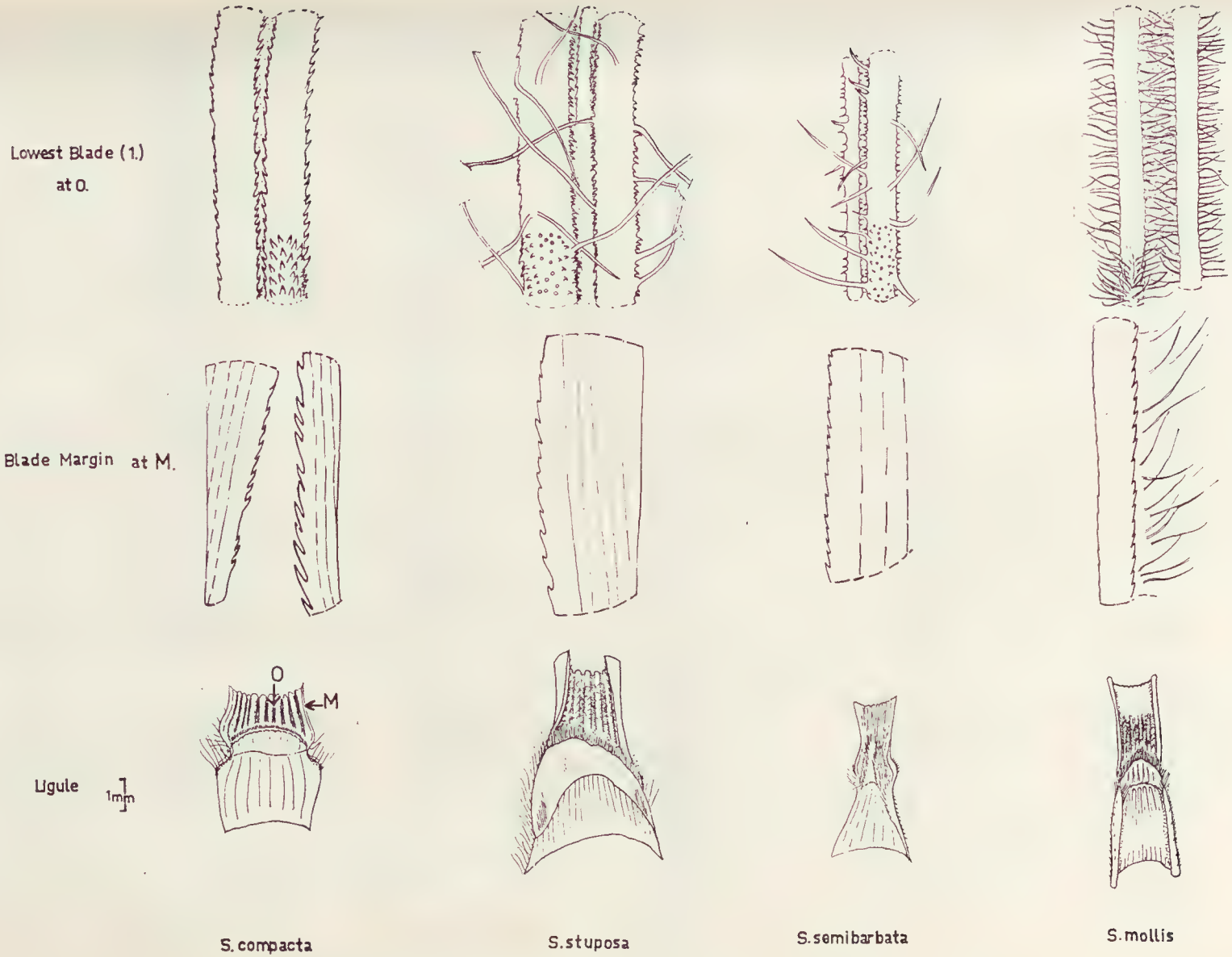
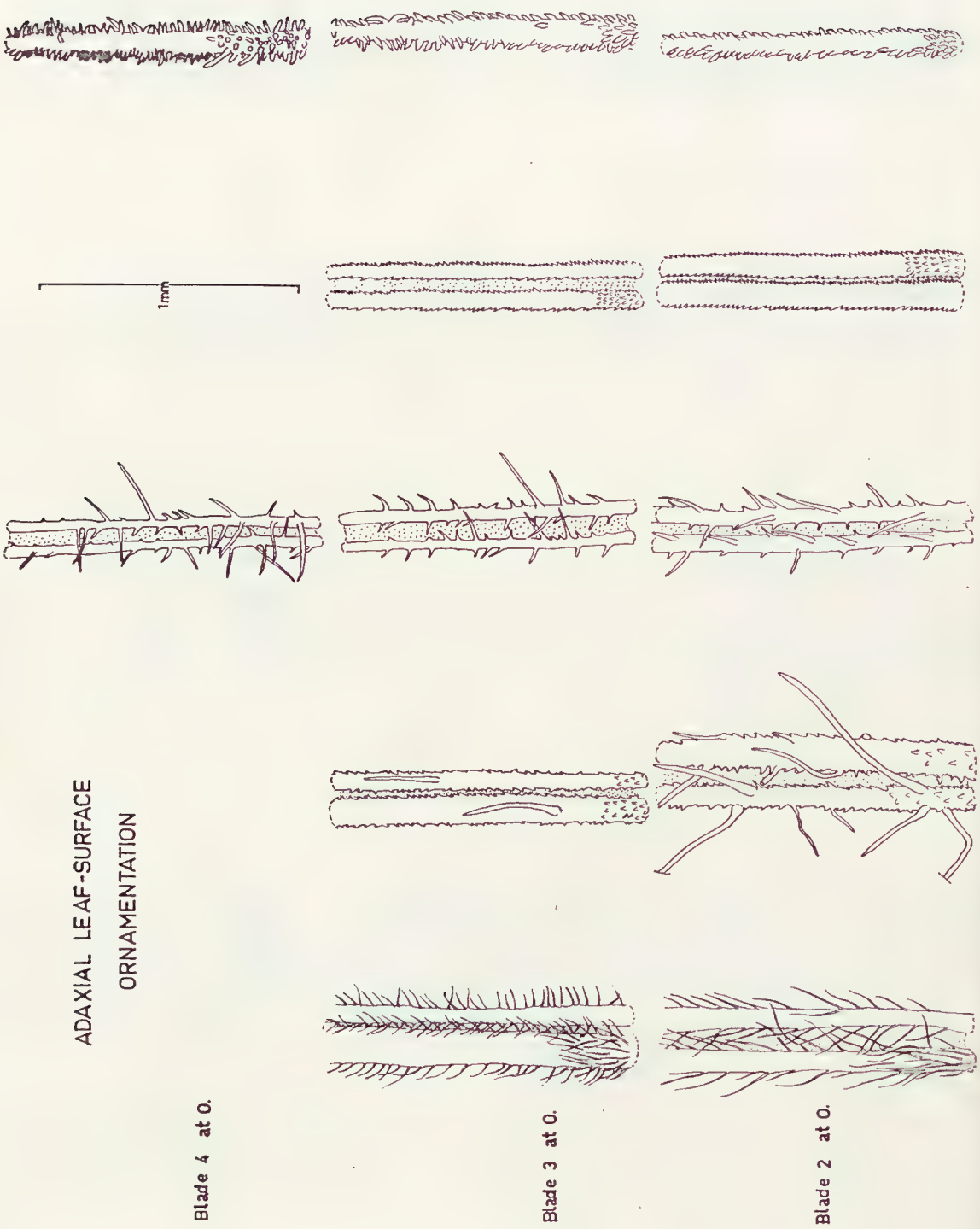


FIG. 1.—Blade characters:—Adaxial leaf surface ornamentation x 40. Blade margin x 40. Ligule x 5.


ADAXIAL LEAF-SURFACE
ORNAMENTATION
1mm
Blade 4 at 0.
Blade 3 at 0.
Blade 2 at 0.

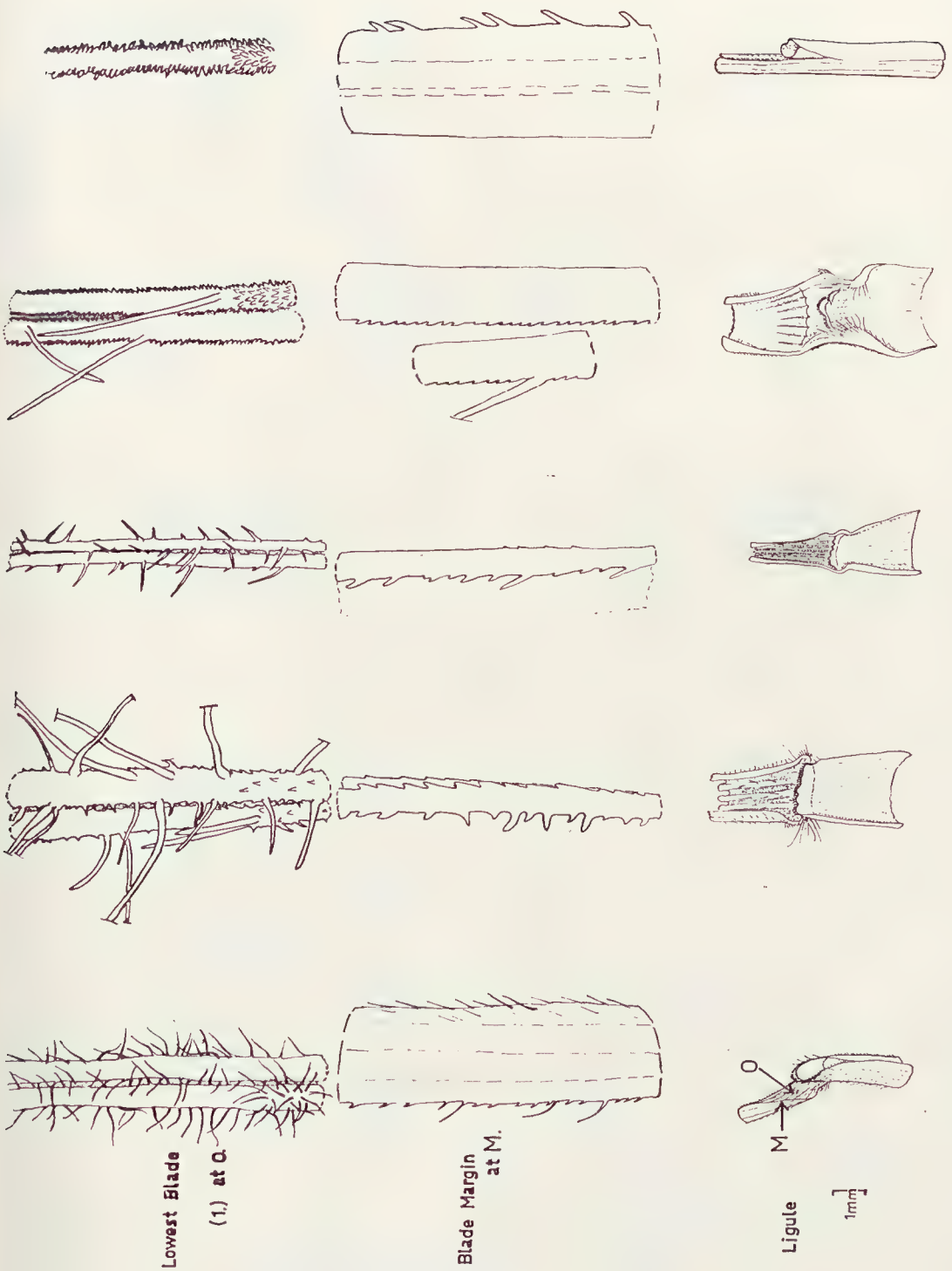


FIG. 2.—Blade characters:—Adaxial leaf surface ornamentation x 40. Blade margin x 40. Ligule x 5.

Lemmas actual size
S.aphylla
S.pubescens
S.nervosa
S.stuposa
S.semibarbata
S.mollis
S.compacta
S.teretifolia
S.variabilis
1 cm
1cm
S.stuposa
S.semibarbata
S.mollis

FIG. 3.—Spikelet characters:—Lemmas of Tasmanian species x 1. A—Lemma + awn x 5. B—Glumes x 5. C—Lemma lobes at junction of lemma and terminal awn x 40. D—Scar on adaxial surface of callus tip x 30.

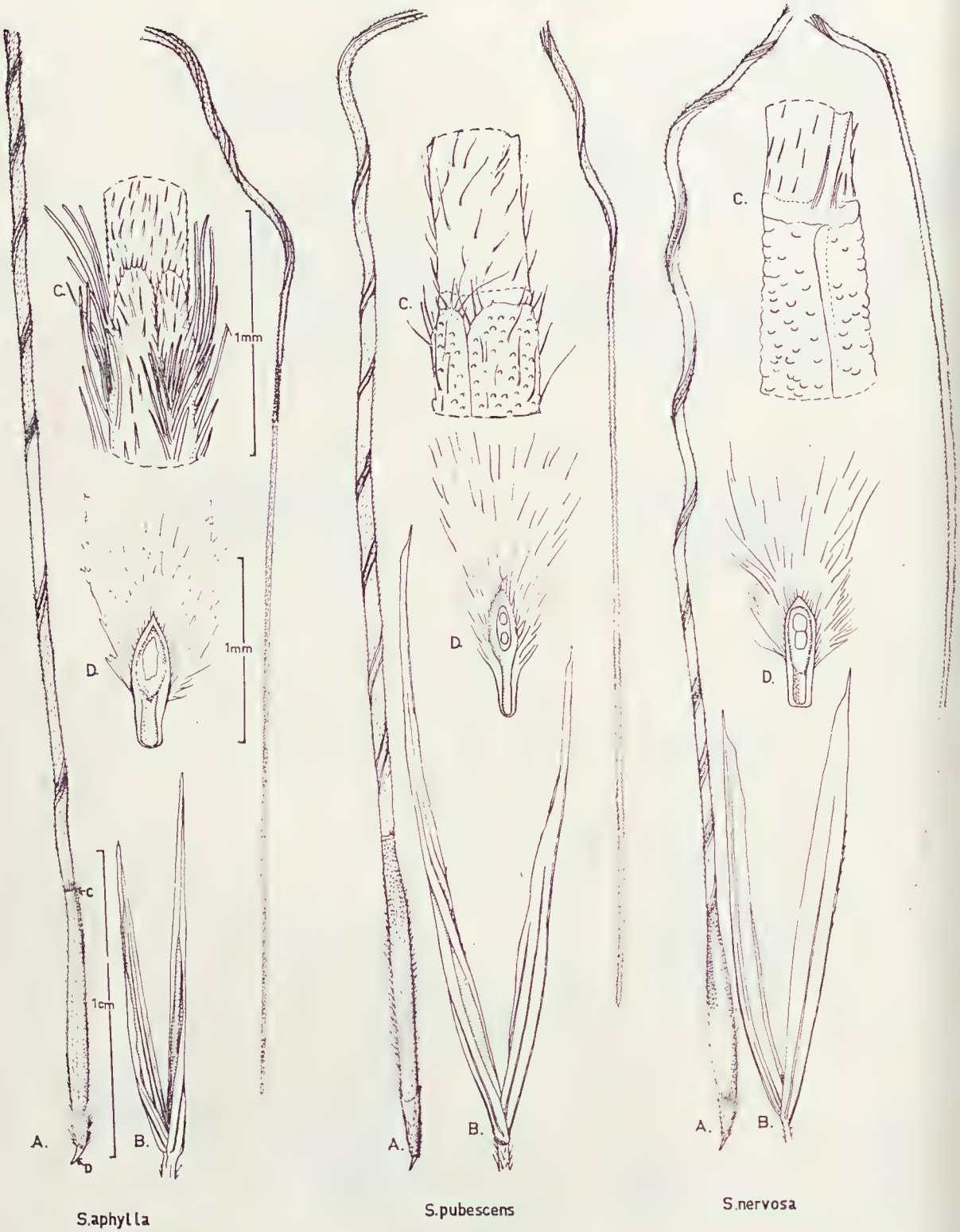


FIG. 4.—Spikelet characters:—A—Lemma + awn x 5. B—Glumes x 5. C—Lemma lobes at junction of lemma and terminal awn x 40. D—Scar on adaxial surface of callus tip x 30.

FIG. 5.—Spikelet Characters:—A—Lemma + awn x 5. B—Glumes x 5. (NOTE: *S. teretifolia*—the upper glume is longer than the lower.) C—Lemma lobes at junction of lemma and terminal awn x 40. D—Scar on adaxial surface of callus tip x 30.

VICKERY, J. W., 1951.—Contributions to the Taxonomy of Australian Grasses. *Stipa nervosa* n. sp. and var. *neutralis* n. var. *Contrib. N.S.W. Herb.* 1: 335, 337. 1951.

WILLIS, J. H., 1962.—*A Handbook to Plants in Victoria.* Vol. 1. *Ferns, Conifers and Monocotyledons.* U.P. Melbourne.

————, 1967.—Systematic Notes on the Indigenous Australian Flora. *Muelleriana.* 1, No. 3, 136.

APPENDIX

Stipa aphylla (Rodway var.) n. sp.

SYNONYM: *Stipa pubescens* R.Br. var. *aphylla* Rodway (1903), p. 262.

Descriptio emend.:

Gramen perenne, caespitosum, gracile, erectum, usque ad 90 cm altum, cum rhizoma brevissima condensata; culmi rigidi, bambusae gracili similes, usque ad 1 mm diametro, leviter striati laeves, glabri, 3-4 nodes, viridis pallidi sed luteus 2 mm supra nodum; nodi brevissimi pubescentes; vaginae ca. dimidium internodorum, leviter striatae, glabrae, stramenescentes et aliquantum inflatae, ultimo exutae post laminas; ligula membrana minuta, ca. 0.1 mm longa, margine crenato minute ciliato; laminae usque ad 4.5 cm longae, rigidiusculae, involutae, rostratratae, ad bases explanatas 1.0 mm latae, exutae inflorescentia emmergente sunt, paginae abaxiales glabrae, paginae adaxiales costatae, costae ca. 0.05 cm latae, pilos sparsos longitudine 0.25-0.025 mm ferentes; panicula angusta ca. 17 cm longa et 3 cm lata, laxissima, in sicco aliquantum contracta, cum ca. 30 spiculis, axi primaria leviter scabra, ramis gracillimis, erectis, scabris, 1-2 natis, pedicellis 1-2 cm longis supraque clavatis; spiculae pallido-viridescentes vel stramineae usque ad fines sed infra purpureae, glumis maturescentibus valide divergentibus; glumae tenues, chartaceae, inaequales, anguste lineare-attenuatae, paullo involutae; inferior gluma longior ca. 13 mm, explanato statu ca. 0.7 mm lata, valide 3-nervata, superior gluma ca. 1.0 cm longa, explanato statu ca. 1.0 mm lata, 3-sub-5-nervata, nervis lateralibus utrinque nervis mediis cum validis; lemma firma, linearis, ca. 9.0 mm longa, cicatricem calli includens 0.5 mm longam, et supra cicatricem caespes pilorum argenteorum 1.3 mm longa, ca. 0.7 mm lata. Lemma est cum pilis argenteis (Munsell-White 10 YR 8/1) corpus brunneum (Munsell-10 YR 3/2) insidet, lemma marginibus in 2 lobos obtusos ca. 0.35 mm longos minute pubescet. Lemma minuta corona pilorum ca. 0.4 mm longorum circum basem aristata est; arista terminalis, minute pubescens, columna brunnea 0.4 mm lata, usque ad 6 cm longa, in sicco statu subtiliter torsiva et geniculata 1 cm infra setam, seta straminea useque ad 2.8 cm longa, arista aliquanto geniculata ad juncturam columnae setaeque; palea ca. 6 mm longa, firma infra marginalibus apiceque hyalinis, in dorso minute pubescens; antherae 3, lineares, ca. 4.5 mm longae; lodiculae 3, ca. 1.5 mm longae.

SYNTYPE: *Tasmania*: Huon Road (Hobart). Rodway, November 1897.

Sheet No. 995. Rodway Collection.

Slender, erect, caespitose perennial, up to 90 cm high, with very short condensed rhizomes; culms rigid, cane-like, up to 1 mm in diameter, finely striate, smooth, glabrous, 3-4 noded, light green but pale-yellow for 2 mm above the nodes; nodes minutely pubescent; sheaths about half the length of the internodes, finely striate, glabrous, becoming straw-coloured and somewhat inflated, ultimately shed after the blades; ligule a minute membrane 0.1 mm long with a crenate minutely ciliate margin; blades up to 4.5 cm long, stiff, inrolled, pointed, 1 mm wide at the base when flattened, shed as the inflorescence emerges, abaxial surface smooth, adaxial surface ribbed, the ribs about 0.05 mm wide and bearing scattered hairs 0.25-0.025 mm long; panicle narrow, very loose, somewhat contracted when dry, with about 30 spikelets, about 17 cm long and 3 cm wide, the main rachis minutely scabrous, the branches very slender, upright, scabrous, 1-2-nate, the pedicels 1-2 cm long and clavate above; spikelets pale-green to straw coloured above and purple below, with glumes widely divergent at maturity; glumes thin, chaffy, unequal, narrowly linear-attenuate, slightly inrolled, the lower glume longer, about 1.3 cm long and 0.7 mm wide when flattened, faintly 3-nerved, the upper glume about 1.0 cm long and 1.0 mm wide when flattened, 3-sub-5-nerved, the lateral nerves of both glumes as strong as the mid-nerve; lemma firm, linear, about 9.0 mm long including the callus-scar 0.5 mm long, and the silvery hair-tuft above the scar 1.3 mm long, lemma 0.7 mm wide, minutely thinly pubescent with silvery hairs (Munsell-White 10 YR 8/1) on a brown body (Munsell—Very dark greyish brown 10 YR 3/2) the margins of the lemma produced into 2 minutely hairy obtuse lobes about 0.35 mm long, the lemma bearing a minute crown of hairs about 0.4 mm long round the awn base; awn terminal, minutely pubescent, the column dark brown, 0.4 mm wide and up to 6 cm long, finely twisted when dry and geniculate 1 cm before the bristle, the bristle straw-coloured and up to 2.8 cm long, the awn slightly kneed at the junction of column and bristle; palea about 6 mm long, firm with hyaline margins and tip, finely pubescent on the back; anthers 3, linear, about 4.5 mm long; lodicles 3, about 1.5 mm long.

LOCALITIES: *Tasmania*: Waterworks (Hobart), Rodway, January 1895; Lower Pipetrack, Fern Tree, Townrow (Ag. Sc. Dept No. 297), 7.3.65; Open woodland, 2 miles N of Bicheno, Townrow (Ag. Sc. Dept No. 298) 13.1.65; Open scrub W side of Channel Highway opposite Alonnah, Townrow, 8.1.67; Bank by Ag. Sc. Dept glasshouse, Uni. Tas., Townrow No. 77, 29.11.67; Margin of open woodland, Barnes Bay, Bruny Island, Townrow No. 147, 1.12.68; Darlington, Maria Island, Townrow No. 205, 23.11.68.

This species, apparently confined to SE Tasmania, closely resembles *S. muelleri* Tate of Victoria and South Australia except that it is about half the size of the latter in all features. It may prove to be closely related, e.g., a member of a polyploid series containing both species, but is considered here as a separate entity because of its geographical isolation. It occurs in the marginal more open areas of undisturbed dry sclerophyll, and is often closely associated with, or growing out of clumps of *Lomandra longifolia* Labill.

TABLE 1.—LEMMA CHARACTERS

Feature	Species								
	Stipa compacta	*S. stuposa*	*S. semibarbata*	*S. mollis*	*S. pubescens*	*S. nervosa*	*S. aphylla*	*S. variabilis*	*S. teretifolia*
LEMMA—Munsell colour	*Dark reddish brown	Dark yellowish brown	Dark brown	Dark brown	Dark yellowish brown	Black above 10 YR 2/1 Dark yellowish brown below	Very dark greyish brown	Black top and bottom 10 YR 2/1 Dark greyish brown between	Dark yellowish brown above 10 YR 4/4 Dark brown below 10 YR 3/2
Seen with the naked eye	5 YR 3/4	10 YR 4/4	10 YR3/3	10 YR 3/3	10 YR 3/4	10 YR 4/3	10 YR 3/2	10 YR 4/2	
BODY—Shape	*Fusiform	Narrowly obovate	Narrowly obovate	Almost linear	*Linear	Narrowly obovate	*Linear	*Fusiform	*Elliptical
Dimensions(+callus)approx.	9.0×1.0 mm	10.0×1.2 mm	9.5×1.0 mm	10.0×0.8 mm	11.0×0.6 mm	8.0×0.9 mm	9.0×0.7 mm	6.0×0.8 mm	11.0×1.1 mm
Munsell colour	Dusky red 2.5 YR 3/2	Brown/dark brown 7.5 YR 4/4	Very dark brown 10 YR 2/2	Dark reddish brown 5 YR 3/3	Dusky red 2.5 YR 3/2	Black 10 YR 2/1	Very dark greyish brown 10 YR 3/2	Dark brown 7 YR 3/2	Dark brown 7/YR 4/4 to 3/2
Surface sculpturing	top 1/3 minutely pimpled	..	Upper 0.5 mm minutely pimpled	..	top 1/3 minutely scabrid	Upper 1/2 minutely scabrid	..	top 1/5 minutely pimpled	..
HAIR ORNAMENT—									
Body—Approx. length	0.5 mm	0.5 mm	0.5 mm	0.3 mm	0.2 mm	0.4 mm	0.2 mm	0.3 mm	*1.5 mm
Density	moderate	moderate	sparse	fairly dense	fairly dense	sparse	sparse, in lines	sparse, curved	*Very dense
M. colour	Yellow 2.5 YR 8/6	Yellow 10 YR 8/6	Yellow 10 YR 8/6	Very pale brown 10 YR 8/4	Reddish yellow 7.5 YR 6/8	Yellowish brown 10 YR 5/6	White 10 YR 8/1	Yellow 10 YR 8/6	White 10 YR 8/1
Awn hairs—Approx. length	0.2 mm	0.5 mm	*1.0 mm	*2.0 mm	0.1 mm	0.1 mm	0.1 mm	0.05 mm	0.2 mm
Extent	to end of column	to end of column	to end of column	*ca 1/3–1/2 way up seta	to end of column	to end of column	to end of column	to end of column	to end of column
Hair-crown—Approx. length	1 mm	*3 mm	..	..	..	..	0.3 mm	0.3–0.1 mm	..
Density	sparse	*moderately dense	..	..	..	..	sparse	very sparse	..
Callus hair tuft—Approx. length	2.0 mm	*3.5 mm	2.0 mm	3.0 mm	2.0 mm	1.4 mm	1.2 mm	1.4 mm	0.8 mm
M. colour	Same as body hairs	Brownish yellow 10 YR 6/6	same as body hairs	Very pale brown 10 YR 8/3	Yellow 10 YR 7/8	same as body hairs	Pale yellow 2.5 YR 8/4	same as body hairs	Yellow 2.5 YR 8/8
CALLUS SCAR—Approx. length	0.76 mm	0.56 mm	0.56 mm	0.65 mm	0.70 mm	0.60 mm	0.75 mm	*0.30 mm	*0.50 mm
Trough	well-defined, narrow	shallow, narrow	shallow, narrow	shallow, broader	shallow, narrow	shallow, broader, end blunt	shallow, broader, end blunt	well defined, *narrow	*shallow, broad
AWN COLUMN—Approx. diam. at base	0.2 mm	0.3 mm	0.3 mm	0.3 mm	*0.5 mm	0.3 mm	0.3 mm	0.2 mm	0.4 mm
Approx. length	3 cm	3 cm	3 cm	*Column and bristle hardly differentiated	*4–4.5 cm	3.5 cm	3.6 cm	*1.5 cm	1.1 cm
No. times kneed	twice	twice	twice	*once curved	twice	twice	once (twice)	*once curved	twice
Approx. length to 1st knee	2 cm	1.5-2 cm	2 cm	1.8 cm to major curve	3 cm	2.5 cm	3.6 cm (2.8 cm)	1.1 cm to major curve	*0.5 cm
LEMMA LOBES—Approx. length	0.125 mm	0.15 mm	up to 0.25 mm	0.10 mm	..	..	0.35 mm	0.16 mm	*1.2 mm
Shape	pointed	rounded	ragged	pointed	..	..	obtuse	ovate	ovate
Margin	serrulate	coarsely dentate	serrulate	minutely toothed	A few hairs in position of lobes, up to 0.15 mm long	..	Ciliate, cilia up to 0.05 mml	hairless	coarsely hairy
FIGURE NUMBER	5	3	3	3	4	4	4	5	5

N.B.—Characters marked * are useful diagnostic features.

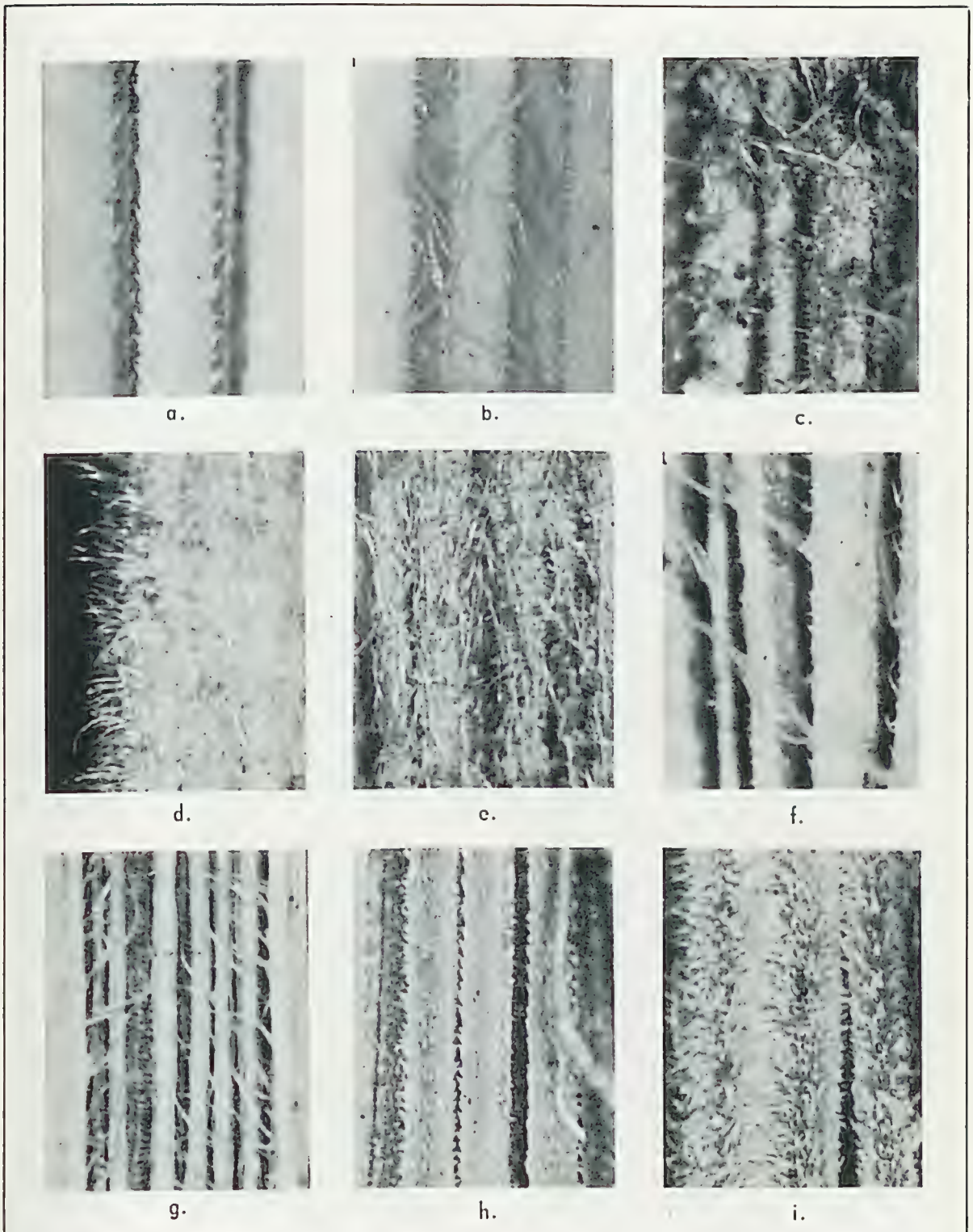


PLATE 1.—Adaxial leaf surface ornamentation within 1 cm of the ligule on the lowest culm-blade x 80.
a. *Stipa compacta* b. *S. stuposa* c. *S. semibarbata*
d. *S. mollis* e. *S. pubescens* f. *S. nervosa*
g. *S. aphylla* h. *S. variabilis* i. *S. teretifolia*

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THE EFFECT ON WOOL GROWTH IN THE NEW ZEALAND ROMNEY OF DIETARY SUPPLEMENTS OF NORMAL AND TREATED CASEIN

By

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(*Communicated by Dr W. Bryden*)

(With four text figures)

ABSTRACT

An experiment was conducted to determine the effect of chemically treated casein supplements on winter wool growth. All sheep were housed in individual pens and fed a basic diet of chopped hay and oat grain at two levels—half the sheep received a maintenance ration calculated on body weight, and the other half received a half-maintenance ration. Within each of these two groups, a further subdivision was effected. One group received 30 g of untreated casein, one group 60 g of untreated casein, a third group was fed 30 g of treated casein and the fourth group received 60 g of treated casein per day. This situation was similar at both levels of basic diet.

All sheep were weighed each week and their weights were recorded. Small but positive increases in body weight were noted, and the relationship between casein and this increase is discussed.

A comparison of treated versus untreated casein was made each month for five months, commencing in April 1968, and concluding in September 1968, and this comparison was considered in terms of wool weight, fibre length and fibre diameter. Similarly, a study of energy levels and treatment of casein was made and the significance of these results are discussed.

INTRODUCTION

The rate of production of keratinised fibres from skin follicles in sheep can be profoundly influenced by nutrition. Some of the earliest controlled experiments demonstrating this fact appear to be those reported by Weber (1931) and Fraser and Nichols (1934). Although there were other reports in the literature which suggested that wool growth was probably affected by nutritional factors, these were concerned with observations of seasonal variations in wool growth of grazing animals (Lush and Jones, 1923); Duerden and Bosman, 1927; Hardy and Tennyson, 1930; Burns, 1931).

During the late 1920s and early 1930s a substantial controversy developed around the problem of whether or not the sheep could synthesise cysteine (Marston and Robertson, 1928; Barritt and King, 1926, 1929; Rimington, 1929; Rimington and Bekker, 1932; Pollard and Chibnall, 1934). At this time, because of the relatively large amount found in wool, cysteine was regarded as an essential amino acid for wool growth. An increase in wool growth due to a supplement of blood meal fed to grazing sheep was inferred by Marston (1932) to be due to the intake of cystine contained in the blood meal. He also attributed the superiority of a supplement of yeast as compared with casein for wool growth to the higher cystine content of yeast. The first reported response of wool growth to the administration of a sulphur containing amino acid was given by Marston (1935). The biological significance of methionine was not known at this time.

Under normal circumstances, ruminants make inefficient use of high protein diets. It has been shown that some proteins are readily degraded by rumen micro-organisms to ammonia, a large part of which may then be absorbed and excreted as urea. When dietary protein content is high, the extent of protein degradation probably exceeds protein synthesis by rumen micro-organisms (McDonald, 1948). Thus substantial amounts of dietary protein may be lost to the animal. Considerable losses of nitrogen due to ammonia production in the rumen have been demonstrated with protein-rich meals and soluble proteins such as casein (McDonald, 1952; Annison, *et al.*, 1954; Chalmers and Synge, 1954). However, nitrogen retention and conversion to animal products such as wool are enhanced when proteins are administered directly into the abomasum or duodenum (Chalmers, *et al.*, 1954; Reis and Schinckel, 1963, 1964).

The latest development in the administration of protein into the abomasum or duodenum is to use protein protected from rumen microbial degradation by chemical modification (McDonald, 1967). Any protection procedure would need to leave the protein in a form capable of digestion and absorption further along the alimentary tract so that the protein could be utilised. The pH differential between the rumen, normally above pH6, and the abomasum, normally below pH3, allows scope for reversal of the effects of coating or chemical treatments.

Sheep produce wool at the maximal rate of which they are capable for only a brief period in each

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year (Williams and Schinckel, 1962). Under New Zealand conditions Romney sheep produce three times as much wool during the the maximal period as in the minimal period (Story and Ross, 1960). This leads to tender wool, and often a break in the staple which results in increased fibre breakage during processing, particularly in combing. Some of this difference can be accounted for by nutrition, and so using pen fed sheep, this experiment set out to find whether the trough of wool growth during the minimal period could be partially or completely eliminated by supplementing the basic diet with casein protected from rumen microbial degradation.

MATERIALS AND METHODS

1. Plan of Experment

The plan provided for eight groups each of five sheep. Two different levels of basic ration were used, maintenance and half maintenance, and superimposed on these was the feeding of two kinds of casein, each at two levels. The eight groups are shown in Table I.

TABLE I—OVERALL PLAN OF EXPERIMENT

0.5 Maintenance (159 g chaffed hay—272 g whole oats/day)

Supplement	*Name of Group*
+30 g casein/day	0.5M/C30
+60 g casein/day	0.5M/C60
+30 g treated casein/day	0.5M/TC30
+60 g treated casein/day	0.5M/TC60

1.0 Maintenance (318 g chaffed hay—545 g whole oats/day)

Supplement	*Name of Group*
+30 g casein/day	1.0M/C30
+60 g casein/day	1.0M/C60
+30 g treated casein/day	1.0M/TC30
+60 g treated casein/day	1.0M/TC60

2. Experimental Sheep

(a) Selection of Sheep

The experimental sheep were five-year-old Romney ewes that had been retained in a commercial flock. All ewes had lambed and reared a lamb or lambs in the four previous years. Forty were selected mainly on the basis of body size and similar wool type and were identifiable by ear tag. The forty selected were allocated at random to the eight groups shown in Table I.

The intention was that experimental work should not be complicated by pregnancy and lactation and reasonable steps were taken to keep the experimental ewes segregated prior to the commencement of feeding regimes. However, as the experiment progressed, it became apparent that some of the ewes were pregnant, and pregnancy toxaemia in some provided an added complication. The best that could be done was to remove lambs from those ewes that lambed, within forty-eight hours of birth. It would be wrong to assume that pregnancy had no effect on wool production but this effect is likely to have been small. Pregnancy is not by any means the major cause of low winter production since the seasonal rhythm of wool production is obvious in dry ewes (Ferguson, *et al.*, 1949) and in both dry ewes and lambs (Coop, 1953). However, pregnancy and lactation together have a strong influence on seasonal differences in wool production (Bosman, 1935; Jones, *et al.*, 1944).

(b) General Management of Sheep

On 30 April 1968, all sheep were allotted at random to individual pens. They had free access to water at all times and were fed daily in the mornings.

Because of the well-known lag in attainment of equilibrium in wool production following change in nutritional level (Marston, 1948), management was divided into two phases, pre-experimental and experimental. The former lasted one month and the latter four months. Calculation of maintenance diets was made on the basis of W 0.73 where W is the body weight of the sheep in Kg. Sheep were fed the amounts as calculated by Coop (1962).

TABLE II—MAINTENANCE RATIONS FED TO SHEEP OF VARYING WEIGHTS

Live Weight (Kg)	*Maintenance Ration* Kg DOM/day
54.5	0.48
63.6	0.54
72.7	0.58

3. Measurement of Wool Growth

At the commencement of the trial the sites for wool sampling were delineated on each sheep. The square of 100 cm^2 was positioned on the right side of the backbone approximately one hand span ventrally, with the rear margins of the 100 cm^2 area over the last rib. This region of the side is in common use in fleece sampling and is referred to as 'mid-side' (Turner, 1956).

Wool clipped from the right 'mid-side' area every twenty-eight days was used for the determination of clean wool production. The wool was removed from the area with an 'Oster' electric clipper using a clipping head number 50, and size 000.

The five samplings over the course of the investigation are given in Table III.

TABLE III—WOOL SAMPLING PERIODS

Sample Number	*Date of Clipping*	*Growth Period*
1. Pre-experimental	28.5.68	1.5.68–28.5.68
2. Experimental	25.6.68	29.5.68–25.6.68
3. Experimental	23.7.68	26.6.68–23.7.68
4. Experimental	20.8.68	24.7.68–20.8.68
5. Experimental	17.9.68	21.8.68–17.9.68

Each 'mid-side' sample of wool was weighed and recorded as clean dry wool.

4. Measurement of Fibre Length

The fibres from the twenty-eight-day clippings were too short for any of the conventional fibre length measurement techniques to be used. A projection method was developed based on the suggestion of Chapman (1960). Random subsamples of approximately 100 fibres were mounted

on cellulose adhesive tape fixed to 2" x 2" glass slides. A suitable refraction was thus provided by the air layer 'trapped' around each fibre.

The fibre images were projected through a standard air cooled slide projector with a 45° mirror suspended in front and supported at a suitable height to provide an image magnification of 10 x upon the bench below. Measurements across the projected field revealed no significant error due to optical aberration.

5. Measurement of Fibre Diameter

The projection microscope method is generally accepted as the most accurate technique for determining fibre diameter (Anderson and Palmer, 1948, 1951a, 1951b; Palmer, 1951; I.W.T.O., 1952; Anderson and Benson, 1953; British Standards, 1953; American Society for Testing Materials, 1961; Kritzinger, Linhart and Van der Westhuyen, 1964). Short fibre lengths from a random subsample were mounted in Canada balsam on a 3" x 1" microscope slide and projected at 500 x magnification (1 mm on image=2 microns). The diameters of 250 fibres were measured and recorded.

6. Statistical Treatment of Data

The experiment was designed to have five replications of eight treatments arranged in a 2 x 2 x 2 factorial design. Data were dealt with by analysis of variance, and 'Student's' t-distribution test was applied to each individual treatment within the analysis of variance. The significance level and minimum difference required for significance were calculated and applied to the data.

RESULTS

1. The Effect of Level of Basic Ration and of Casein Supplementation on Body Weght

Mean body weights for all groups except 0.5M/C60 and 1.0M/TC30 were complicated by pregnant sheep within the groups. Fig. 1 represents the adjusted body weights making allowance for pregnancy.

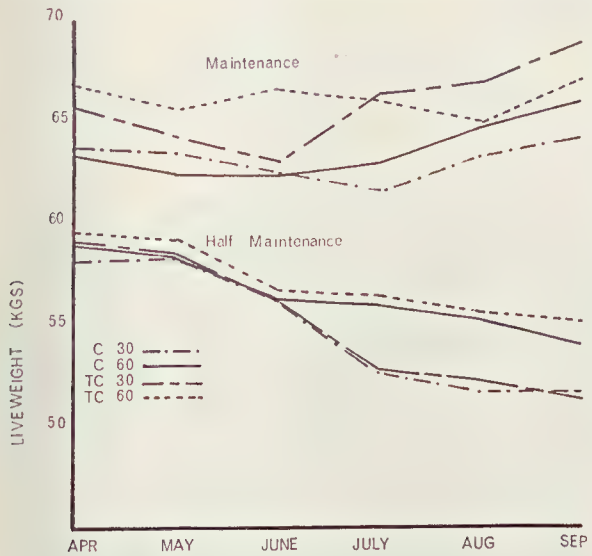

FIG. 1 Adjusted Group Mean Liveweights

As expected all sheep in the half-maintenance energy group lost weight, but during the last two months of the trial their weights remained relatively constant. Sheep on maintenance energy rations all gained small but positive amounts in body weight during the experimental period.

2. The Effect of Level of Basic Ration and Casein Supplementation on Weight of Wool Grown

Group mean weight of wool grown throughout the pre-experimental and experimental periods is given in Fig. 2 (*a*) and (*b*).

At no stage during the experimental period was there any significant difference between 30 g/day and 60 g/day of the casein (Table IV), although significance was approached during the last three months of the trial.

The energy level of the ration, as expected, was highly significant in terms of weight of wool grown for the last three periods of the trial. The fact that there was no significant difference for the first of the experimental periods is possibly due to the carry-over effect from the pre-experimental period.

3. The Effect of Level of Basic Ration and Casein Supplementation on Fibre Diameter

Group mean measurements of fibre diameter throughout the pre-experimental and experimental periods are given in Fig. 3 (*a*) and (*b*).

From the results given in Table V, the level of casein in the ration (i.e., 30 g/day *v* 60 g/day) was significant for the periods 29 May to 25 June 26 June to 23 July and 24 July to 20 August inclusive. For the rest of the trial the level of casein was not significant.

The energy level in the ration (i.e., 0.5M *v* 1.0M) had a significant effect on fibre diameter during the periods 26 June to 23 July and 24 July to 20 August only. Significance was approached in the last period.

Treatment of casein with formalin had a significant effect on fibre diameter during the periods 26 June to 23 July and 24 July to 20 August. However, the complication of pregnancy could have been a major contributing factor in the low level of significance since all sheep lambed in the period 24 July to 20 August, and fibre diameter readings for this period are likely to be unrealistic.

4. The Effect of Level of Basic Ration and Casein Supplementation on Fibre Length

Group mean measurements of fibre length throughout the pre-experimental and experimental periods are given in Fig. 4 (*a*) and (*b*).

From the results in Table VI, the level of casein in the ration is significant only in the periods 29 May to 25 June, and 21 August to 17 September. In the two intervening periods significance is approached. Once again, the complication caused by pregnancy in this period could be a contributing factor.

The energy level in terms of fibre length is only significant in the periods 29 May to 25 June and 26 June to 23 July. During the period in which all sheep lambed, that is 24 July to 20 August, the pregnancy factor may have been more of a complication than was first thought.

Treatment of casein in the ration showed a significant response for all months of the experimental period except 26 June to 23 July.

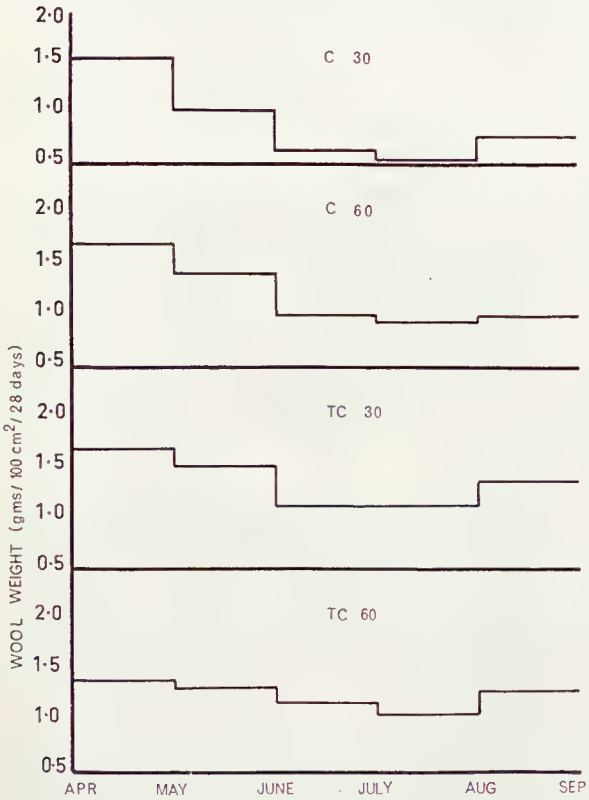

FIG. 2(a) Group Mean Wool Weights (Half Maint.)

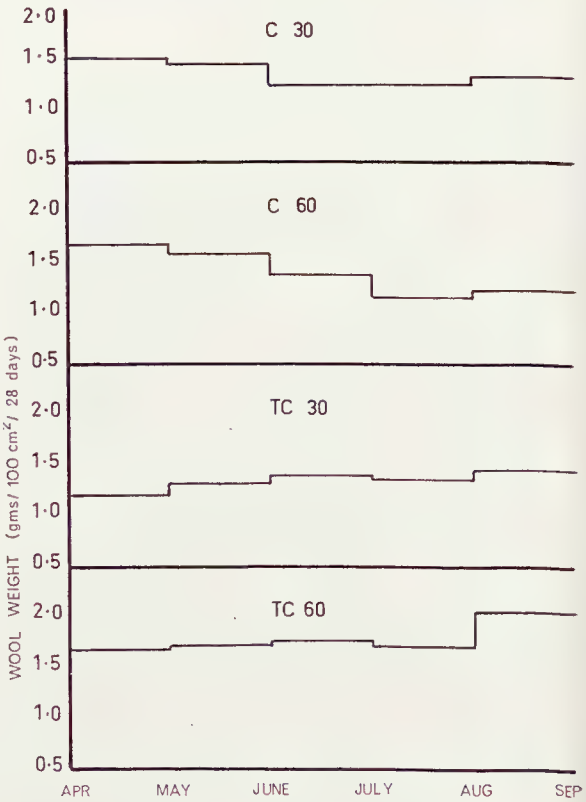

FIG. 2(b) Group Mean Wool Weights (Maint.)

DISCUSSION

The increase in the rate of wool growth obtained in this experiment when casein, chemically treated with formalin, was fed, is in agreement with the results of Reis and Schinckel (1961, 1963). The extra energy available from the casein was far too small to account for the increases in wool growth which were obtained. A similar untreated supplement may not result in increased wool growth when added to the diet and exposed to ruminal activity, and this is borne out in the results of those sheep receiving untreated casein. This agrees with the lack of wool growth response to levels of dietary protein above 8% in the experiments reported by Ferguson (1959). It thus appears that protein, apart from its energy value, can specifically stimulate wool growth and that the S-amino acids may be especially important. However, the specific function of cysteine in stimulating wool growth is not known at present.

Although cysteine and methionine are present in the form of S-amino acids, their exact amounts are not known. The mechanism of action of these two S-amino acid supplements in stimulating wool growth is obscure but several possibilities exist (Reis and Schinckel, 1963). There may be some general anabolic effect which indirectly affects keratin synthesis in the follicles. There is an indication of such a general anabolic effect because there was a positive increase in body weight in all sheep receiving a maintenance energy ration plus casein, but not affected by pregnancy. There may also be direct effects on keratin synthesis in the follicle. Cysteine may be the limiting amino acid for keratin synthesis as suggested by Marston (1935, 1948, 1955) and the feeding of casein may simply increase the supply of substrate available for keratin synthesis. There may also be some other specific effect of cysteine or of the sulphur or sulphydryl component of the molecule, in the

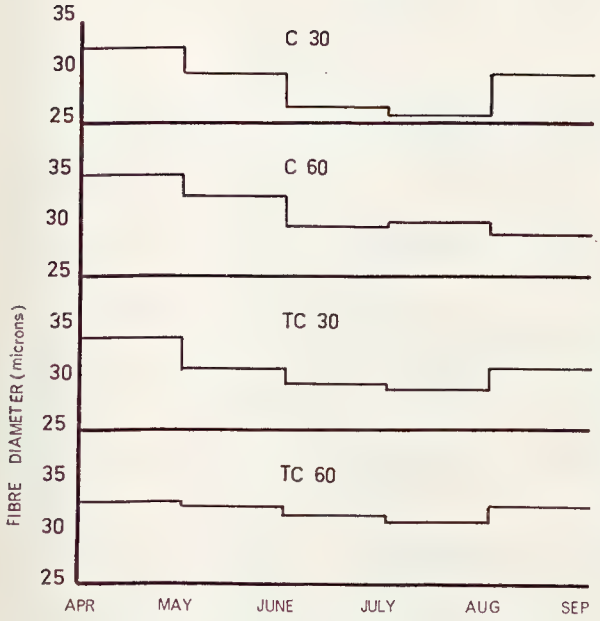

FIG. 3(a) Group Mean Fibre Diameters (Half Maint.)

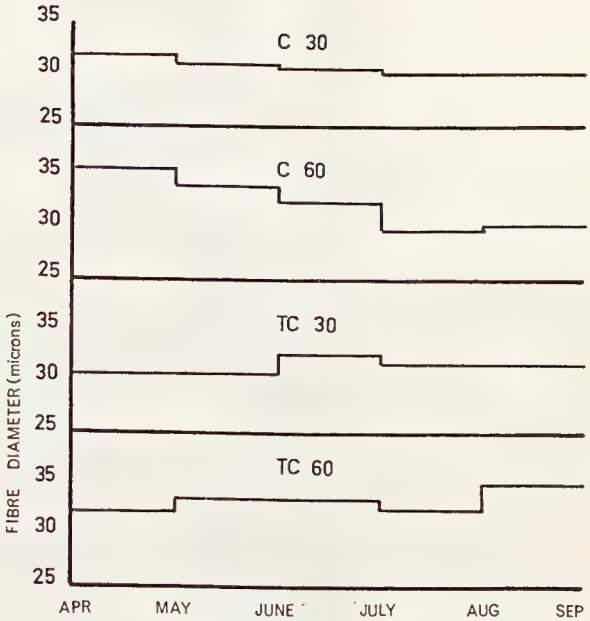

FIG. 3(b) Group Mean Fibre Diameters (Maint.)

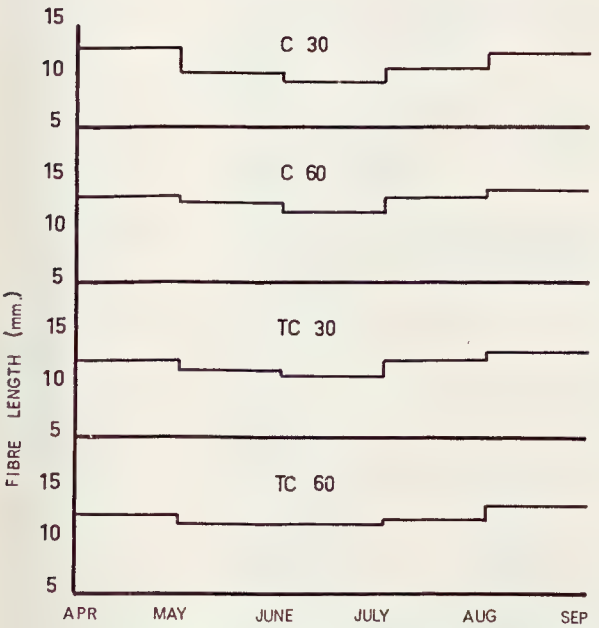

FIG. 4(a) Group Mean Fibre Length (Half Maint.)

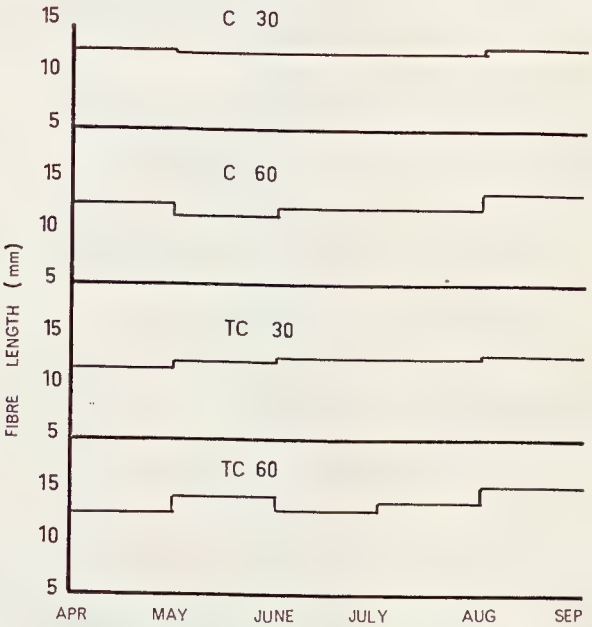

FIG. 4 b Group Mean Fibre Length (Maint.)

TABLE IV—THE EFFECT ON WEIGHT OF WOOL GROWN OF LEVEL OF CASEIN IN THE RATION (30 g/DAY *v* 60 g/DAY), ENERGY LEVEL OF RATION (0.5 M *v* 1.0 M) AND TREATMENT OF CASEIN (FORMALIN TREATED *v* UNTREATED)

	Pre-experimental		Experimental					
Period	1.5.68–28.5.68		29.5.68–25.6.68		26.6.68–23.7.68		24.7.68–20.8.68		21.8.68–17.9.68	
Casein level—	*Wt (g)*	*Diff.*	*Wt (g)*	*Diff.*	*Wt (g)*	*Diff.*	*Wt (g)*	*Diff.*	*Wt (g)*	*Diff.*
30 g	1.50		1.34		1.11		1.08		1.24	
60 g	1.63	0.13§	1.53	0.19§	1.22	0.11§	1.23	0.15§	1.39	0.15§
Energy level—										
0.5 M	1.59		1.34		0.99		0.93		1.11	
1.0 M	1.54	—0.05§	1.54	0.20§	1.46	0.47‡	1.38	0.35‡	1.52	0.41‡
Casein treatment—										
Untreated	1.50		1.34		1.11		1.07		1.23	
Treated	1.63	0.13§	1.53	0.19§	1.34	0.23†	1.22	0.15§	1.39	0.16§

Minimum difference required for significance	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%
	0.21	0.30	—	0.24	0.31	—	0.16	0.21	0.28	0.18	0.24	0.32	0.18	0.24	0.33

* P <0.05; † P <0.01; ‡ P <0.001; § Not significant

TABLE V—THE EFFECT ON FIBRE DIAMETER OF LEVEL OF CASEIN IN THE RATION (30 g/DAY *v* 60 g/DAY), ENERGY LEVEL OF RATION (0.5 M *v* 1.0 M) AND TREATMENT OF CASEIN (FORMALIN TREATED *v* UNTREATED)

	Pre-experimental		Experimental					
Period	1.5.68–28.5.68		29.5.68–25.6.68		26.6.68–23.7.68		24.7.68–20.8.68		21.8.68–17.9.68	
Casein level—	*Diam.* (μ)	*Diff.*	*Diam.* (μ)	*Diff.*	*Diam.* (μ)	*Diff.*	*Diam.* (μ)	*Diff.*	*Diam.* (μ)	*Diff.*
30 g	32.4		30.8		30.0		29.3		30.8	
60 g	34.2	1.8§	33.4	2.2*	32.1	2.1*	31.1	1.8*	31.9	1.1§
Energy level—										
0.5 M	33.7		32.7		29.5		30.1		31.7	
1.0 M	33.8	0.1§	32.5	—0.2§	32.5	3.0†	32.2	2.1*	32.9	1.2§
Casein treatment—										
Untreated	32.3		31.8		29.0		29.3		30.8	
Treated	34.1	1.8§	33.4	1.6§	32.0	3.0‡	31.1	1.8*	31.9	1.1§

Minimum difference required for significance	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%
	2.23	2.98	—	1.88	2.51	—	1.80	2.41	—	1.68	2.25	—	1.77	2.37	—

* P <0.05; † P <0.01; ‡ P <0.001; § Not significant

TABLE VI—THE EFFECT ON FIBRE LENGTH OF LEVEL OF CASEIN IN THE RATION (30 g/DAY *v* 60 g/DAY), ENERGY LEVEL OF RATION (0.5 M *v* 1.0 M) AND TREATMENT OF CASEIN (FORMALIN TREATED *v* UNTREATED)

	Pre-experimental				Experimental					
Period	1.5.68–28.5.68		29.5.68–25.6.68		26.6.68–23.7.68		24.7.68–20.8.68		21.8.68–17.9.68	
Casein level—	*Length (mm)*	*Diff.*	*Length (mm)*	*Diff.*	*Length (mm)*	*Diff.*	*Length (mm)*	*Diff.*	*Length (mm)*	*Diff.*
30 g	12.5		11.8		11.6		12.2		12.9	
60 g	13.0	0.5§	12.7	0.9*	12.3	0.7§	12.9	0.7§	14.2	1.3†
Energy level—										
0.5 M	12.8		11.6		11.1		13.2		13.2	
1.0 M	13.6	0.8§	12.8	1.2†	12.8	1.7‡	13.0	−0.2§	13.9	0.7§
Casein treatment—										
Untreated	12.5		11.8		12.5		12.2		12.9	
Treated	13.9	1.4§	13.7	1.9‡	12.3	−0.2§	13.9	1.7‡	15.1	2.2‡

Minimum difference required for significance	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%	5%	1%	0.1%
	1.8	2.1	—	0.73	0.98	1.29	0.86	1.15	1.51	0.82	1.10	1.45	0.79	1.06	1.39

* P <0.05; † P <0.01; ‡ P <0.001; § Not significant

follicle. This effect may be a stimulation of mitotic activity in the follicle bulb since there is much evidence that sulphydryl groups play an important role in mitosis (Stern, 1959; Mazia, 1959, 1961). Also there may be increased production of co-factors important in protein or energy metabolism. Thus, cysteine is involved in the synthesis of glutathione and co-enzyme A (Reis and Schinckel, 1963).

Restriction of wool growth by poor nutrition is associated with a reduction in length and diameter of individual fibres (Daly and Carter, 1956). It was considered by Fraser (1934) that fibre diameter was more susceptible to nutritional influence than was fibre length and Galpin (1948) found that changes in length precede changes in diameter. From this she suggested that diameter is influenced less by poor nutrition than is length.

Under normal feeding regimes, Romney sheep fed a maintenance ration throughout the winter exhibit a seasonal decline in wool production. This decline is caused by a number of factors, the two most important being photoperiodic stimulus and nutrition. While the photoperiodic stimulus cannot be altered under normal circumstances, the feeding regime can be. In the present experiment sheep fed a half maintenance energy ration showed an accentuated decline in wool production and the greater proportion of this can be attributed to the fact that these sheep were in a state of negative energy balance. Feeding of treated casein in this experiment has arrested this seasonal decline of wool production and so although no great increases in wool weight due to the feeding of treated casein are apparent, when considered in terms of seasonal wool production, the differences are very real.

In this experiment, sheep receiving a maintenance energy ration plus untreated casein showed a reduction in weight of wool grown when compared with those receiving treated casein, and this reduction was accompanied by a reduction in fibre diameter only. Earlier workers suggested that change in fibre diameter was mainly due to change in the width of the medulla, but recent work (Ryder, 1956a; Henderson, 1965) has shown that changes in diameter of the fibre are accompanied by changes in the thickness of both the cortex and the medulla.

The physical basis of the length/diameter ratio has been shown by Rudall (1955) to be the dimensional structure of the follicle papilla. However, both Fraser (1964) and Henderson (1965) found that although a clear association of these dimensions was demonstrated within sheep the relationship did not hold between sheep.

The length/diameter ratio in the present investigation altered as the nutritional regime improved. In the half maintenance energy group receiving 30 g of untreated casein per day, the effect was seen as a reduction in both length and diameter, the effect on length being greater. Feeding 30 g of treated casein substantially reduced the effect on length. Short (unpublished) and Henderson (unpublished) have noted that at low levels of nutrition any change in fibre dimensions induced by nutritional regime is seen primarily as a reduction in length. In the low energy groups receiving 60 g of untreated casein per day there was less effect on fibre length than in those sheep receiving 30 g per day, and feeding 60 g of treated casein per day produced a proportionately greater effect on fibre diameter than on fibre length.

Sheep in the maintenance energy group receiving untreated casein showed the reduction in wool weight as one of reduction in fibre diameter rather than reduction in length. It was found that while a reduction in fibre diameter occurred in sheep receiving untreated casein, those receiving treated casein showed an increase in fibre diameter. There was a greater proportionate increase in diameter than in length. This agrees with the results of Schinckel (1962) and Reis and Schinckel (1964). Schinckel (1962) observed an increase of 71% in fibre cross-sectional area during casein administration per abomasum and this increase accounted for 46% of the increased wool growth. Schinckel pointed out then that there was no way of determining the relative contributions of rate of cell production and of cell volume changes in cross-sectional area and length of fibres. It is not possible to estimate accurately changes in the mitotic rate of matrix cells from measured changes in fibre output and cortical cell volume, nor to estimate changes in fibre cell volume from observed changes in mitotic rate and fibre output (Short, *et al.*, 1965).

From the wool growth figures obtained in this investigation during the last of the experimental periods it would seem that pregnancy in sheep has a more positive effect on wool growth than was first thought. This has since been shown to be significantly correct (Bryden, unpublished). In the design of the experiment, lambs were removed within forty-eight hours from those sheep which lambed on the presumption that lactation had much more effect on wool growth than did pregnancy. However, Coop (pers. comm.) has shown that any stress effect in terms of wool growth has a long carry-over effect, and so the greater effect which can show up during lactation is most likely a carry-over effect from pregnancy.

The level of casein fed during the experimental period was not a significant factor in terms of weight of wool grown. This indicates either that 30 g per day of casein is as effective as 60 g per day, or that pregnancy in some sheep masked the response. This latter explanation would appear to be the logical one since during the last experimental period the difference between 30 g and 60 g per day of treated casein was much greater than for the rest of the experimental period when some ewes in most groups were pregnant.

A significant relationship between the level of casein and fibre diameter occurred for all but the last period of the experiment whereas significance between level of casein and fibre length only occurred in two periods. This might indicate that fibre diameter is much more sensitive than fibre length to the effects of pregnancy.

A significant relationship between energy level of the ration and wool growth occurred in all but the first of the experimental periods. The fact that no significance was evident during the first period is likely to be due to a carry-over effect from the pre-experimental period. Under ordinary feeding regimes, the rate of wool growth closely fol-

lows the intake so that the greater the intake the greater the wool production. The rate of wool production at very low levels of feeding is understandably very small, but it is apparent and continues at the expense of other tissues.

The relationship between energy level and fibre length was significant during the first two months of the experimental period only, although in the final period significance was approached. Thus, the only period when any real difference was noticed was during 24 July to 20 August, the period in which all pregnant ewes lambed.

Low significant values were obtained for the relationship between energy level and fibre diameter for all periods except 26 June to 23 July. Again, these values approached significance levels and possibly the complication caused by pregnancy may have been an important factor in these results.

It is apparent in the results of this experiment that there was some sort of an interaction between the response of wool growth to administration of treated casein and time, although this cannot be definitely assessed. The magnitude of the response to casein and S-amino acid supplements will obviously depend on how nearly the wool growth rate on the basic diet approaches the genetic potential for wool growth.

In the experiments of Reis and Schinckel (1961, 1963) the intake of basic diet was kept at a moderate level so that wool growth would be well below the maximum.

Although non-significant results were apparent in some instances throughout this investigation, the fact that most approached significance would tend to indicate that the number of sheep per group, five, was not enough. The use of larger numbers per group would most likely have shown these results that approached significance to be in fact significant.

Sheep which received a maintenance ration plus a supplement of casein increased in body weight during the experimental period. This increase, although small, was positive. There seemed to be some increase in favour of those sheep receiving treated casein, regardless of level, over those sheep receiving untreated casein, although the difference was only slight.

Various studies have clearly shown that ruminants can make use of non-protein nitrogen compounds in lieu of a part of the protein intake required for growth and maintenance. The explanation seems to be that micro-organisms in the rumen can use non-protein nitrogen to build their body protein which is in turn digested in the true stomach and intestines. Lofgreen, *et al.* (1947), suggested that the quality of protein as fed in the rations of lambs may be of importance under some conditions. It seems logical to assume that if protein quality has an effect upon the nitrogen retention of lambs that it may have some similar effect upon the gains in weight in feed lot operations.

Comparing control sheep with those receiving DL-methionine or L-cysteine administered into the abomasum, Reis (1967) found that the treated sheep showed small but consistent and positive increases in body weight. In contrast to effects on wool growth there was a progressive increase in body weight with each increment of S-amino acid.

In the present study, the significance of body weight increase is difficult to ascertain, due to the complications caused by pregnancy. For sheep being fed a maintenance ration alone, body weight should remain constant to within ±1 Kg per week, and thus it may be assumed in this case that the increase was due to the supplement of casein.

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REFERENCES

ANDERSON, S. L. and BENSON, F., 1953.—*J. Text. Inst.*, 44: p. 98.

——— and PALMER, R. C., 1948.—I.W.T.O. C'tee Proc., 2: 5.

———, 1951a.—*J. Text. Inst.*, 42: p. 114.

———, 1951b.—*J. Text. Inst.*, 42: p. 137.

ANNISON, E. F., 1956.—*Biochem. J.*, 64: 705.

———, CHALMERS, M. I., MARSHALL, S. B. M. and SYNGE, R. L. M., 1954.—*J. Agric. Sc. Camb.*, 44: 270.

A.S.T.M., 1961.—'American Society for Testing Materials' *Philadelphia Pa.*, 32nd ed.: 828.

BARRITT, J. and KING, A. T., 1926.—*J. Text Inst.*, 17: T386.

———, 1929.—*J. Text. Inst.*, 20: T151.

BOSMAN, V., 1934.—*J. Text. Inst.*, 25: 270.

BRITISH STANDARDS, 1953.

BURNS, R. H., 1931.—*J. Text. Inst.*, 22: T98.

CHALMERS, M. I., CUTHBERTSON, D. P. and SYNGE, R. L. M., 1954.—*J. Agric. Sci. Camb.*, 44: 254.

——— and SYNGE, R. L. M., 1954.—*J. Agric. Sci. Camb.*, 44: 263.

CHAPMAN, R. E., 1960.—Cited by Fraser and Short (1960) in 'Biology of the Fleece'.

COOP, I. E., 1953.—*J. Agric. Sci. Camb.*, 43: 457.

———, 1962.—*J. Agric. Sci. Camb.*, 58: 179.

DALY, R. A. and CARTER, H. B., 1956.—*Aust. J. Agric. Res.*, 7: 76.

FERGUSON, K. A., 1959.—*Nature*, Lond. 184 (1): 907.

———, CARTER, H. B. and HARDY, M. H., 1949.—*Aust. J. Sci. Res.* B2: 42.

FRASER, A. H. H., 1934.—*Nutr. Abstr. and Revs*, 4: 9.

FRASER, I. E. B., 1964.—*Aust. J. Biol. Sci.*, 17: 521.

GALPIN, N., 1948.—*J. Agric. Sci. Camb.*, 38: 303.

HARDY, J. I. and TENNYSON, J. B., 1930.—*J. Agric. Res.*, 40: 457.

HENDERSON, A. E., 1965.—'Biology of the Skin and Hair-growth' (Ed. by Lyne, A. G. and Short, B. F.). Angus and Robertson, Sydney. 446.

I.W.T.O., 1952.—Int. Wool Textile Organization—Standards.

JONES, J. M., WARWICK, B. L., PHILLIPS, R. W., SPENCER, D. A., GODBEY, C. B., PATTERSON, R. E. and DAMERON, W. H., 1944.—*J. Anim. Sci.*, 5: 154.

KRITZINGER, C. C., LINHART, H. and VAN DER WESTHUYZEN, A. W. G., 1964.—*Text. Res. J.*, 34: 518.

LOFGREEN, G. P., LOOSLI, J. K. and MAYNARD, L. A., 1947.—*J. Anim. Sci.*, 6: 343.

LUSH, J. L. and JONES, J. M., 1923.—*Texas Agric. Exp. Sta. Bull.*, No. 311.

MARSTON, H. R., 1928.—*Coun. Sci. Industr. Res. Aust. Bull.*, No. 39.

———, 1932.—*Coun. Sci. Industr. Res. Aust. Bull.*, No. 61.

MARSTON, H. R., 1935.—*J. Agric. Sci. Camb.*, 25: 113.

————————, 1948.—*Aust. J. Sci. Res.*, B1: 93.

————————, 1955.—'Progress in the Physiology of Farm Animals'. (Ed. J. Hammond). Ch. 11 (*Butterworths Scientific Publication*, London).

MAZIA, D., 1959.—'Sulphur in Proteins'. (Eds. R. Benesch, *et al.*) Ch. VIII (Academic Press Inc.: New York and London).

————————, 1961.—'The Cell'. (Eds. J. Brachet and A. E. Mirsky). Vol. 3, pp. 77-412 (Academic Press Inc.: New York).

MCDONALD, I. W., 1948.—*Biochem. J.*, 42: 584.

————————, 1952.—*Biochem. J.*, 51: 86.

————————, 1967.—*Wool Tech. and Sheep Breeding*, XIV: 53.

PALMER, R. C., 1951.—*J. Text. Inst.*, 42: p. 23.

REIS, P. J., 1967.—*Aust. J. Biol. Sci.*, 20: 809.

———————— and SCHINCKEL, P. G., 1961.—*Aust. J. Agric. Res.*, 12: 335.

REIS, P. J. and SCHINCKEL, P. G., 1963.—*Aust. J. Biol. Sci.*, 16: 218.

————————————————, 1964.—*Aust. J. Biol. Sci.*, 17: 532.

REIS, P. J. and WILLIAMS, O. B., 1965.—*Aust. J. Agric. Res.*, 16: 1011.

SCHINCKEL, P. G., 1962.—*Anim. Prod.*, 4 (1): 122.

SHORT, B. F., WILSON, P. A. and SCHINCKEL, P. G., 1965.—'Biology of the Skin and Hairgrowth'. (Ed. by Lyne, A. G. and Short, B. F.). Angus and Robertson, Sydney.

STERN, H., 1959.—'Sulphur in Proteins'. (Eds. R. Benesch, *et al.*). Ch. VII 2 (Academic Press Inc.: New York and London).

STORY, L. G. and ROSS, D. A., 1960.—*N.Z. J. Agric Res.*, 3: 113.

TURNER, H. N., 1956.—*Anim. Br. Abstr.*, 24: 87.

WEBER, A. D., 1931.—*Proc. 24th Ann. Meet. Amer. Soc. Anim. Prod.*, 228.

WILLIAMS, O. B. and SCHINCKEL, P. G., 1962.—*Proc. Aust. Soc. Anim. Prod.*, 4: 38.

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A RECORD OF THE OCEANIC PUFFER FISH *Lagocephalus lagocephalus* (L.), ORDER TETRAODONTOIDEA, FROM KING ISLAND, TASMANIA

By

A. P. Andrews

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(With one text figure and one plate)

ABSTRACT

A specimen of the Oceanic Puffer Fish, *Lagocephalus lagocephalus* (Linnaeus), found on a beach on King Island, Bass Strait is described. This appears to be the first Australian record of this species.

INTRODUCTION

On 20 June 1967, a fish found washed up at Phoques Bay, 39° 40′ S, 143° 55′ 50″ E, King Island, was handed in to the Sea Fisheries Division, Department of Agriculture, Hobart. The specimen was subsequently acquired by the Tasmanian Museum where it was identified as the Oceanic Puffer, *Lagocephalus lagocephalus*. Despite the fact that it was found dead the fish was in an excellent state of preservation and was kept in frozen storage pending its arrival at the museum where it was transferred to liquid preservative. As the specimen appears to be the first record of this tropical species for Australia a description is given of the King Island specimen together with some observations on its probable origin and mode of arrival.

DESCRIPTION

The general form is shown in plate 1. As can be seen from the photograph the anterior air-sac which is characteristic of this group of fishes is not inflated, giving a somewhat wrinkled appearance to the abdomen. The posterior part of the lateral line can be clearly seen, but the position of the anterior branches with the exception of the section over the eye is less certain. The raised ventro-lateral skin fold on the tail mentioned by Smith (1950) is present, but less obvious than the one figured by Templeman (1962).

The caudal fin has the lower rays noticeably longer than the upper rays. This has been mentioned by Ramalho (1931) as a characteristic of the species. Ramalho also describes the short, rather blunted, four rooted spines on the belly. These spines, which in the King Island specimen extend in rows along the belly from about 4 cm behind the snout to within 2 cm of the cloaca, are about 2 mm high and the cross shaped roots are about 1 cm across (fig.).

The nostrils are simple pores on the dorsal surface of the head 2 cm in front of the anterior border of the eye. There are two pairs of nostrils with no associated pits or tentacles. The skin is completely smooth except for the belly and the upper half is dark brownish-black in colour, merging into bluish-silver on the sides. The belly is creamy-white and the caudal, dorsal and upper part of the pectoral fins are a uniform dark brown. The anal and lower part of the pectoral fins are a yellowish-white. The gill slit which appears to partly encircle the base of the pectoral fin is black internally.

The upper and lower bones of the jaws are fused to form the characteristic beak-like structure, each divided by a medium suture and approximately equal in size. The number of vertebrae is seventeen (determined by radiograph). The table gives a list of measurements for the King Island specimen alongside the corresponding measurements for a specimen figured by Templeman (1962) from Newfoundland.

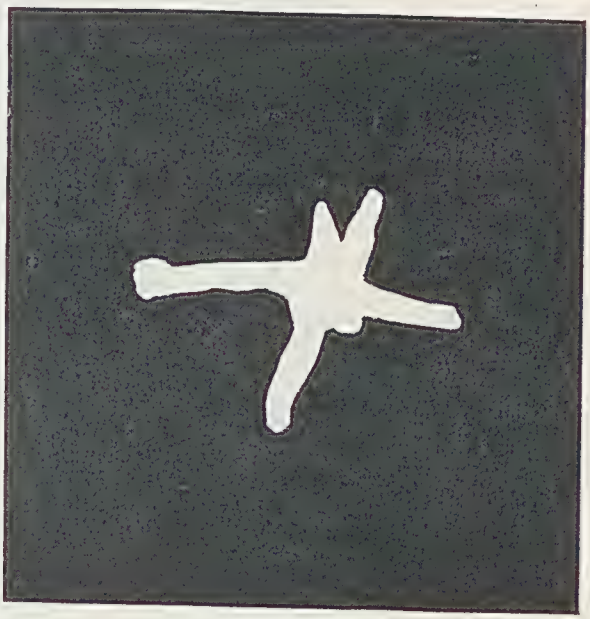

Fig.—Spine from *Lagocephalus lagocephalus* approximately 2 x natural size.

This species is quite distinct and readily distinguishable from all the Tasmanian members of the Tetraodontoidea by:—

(1) The presence of spines on the belly only;
(2) The simple nostrils;
(3) The large size (60 cm); and
(4) The four rooted spines.

DISCUSSION AND CONCLUSIONS

Lagocephalus lagocephalus is described by Ramalho (1931) as being rare in the Northern Atlantic, but more frequent in the Southern Mediterranean and tropical Atlantic Africa. Smith (1950) gives the distribution as 'widespread in the Atlantic and Indian Oceans' and mentions that the species is primarily pelagic. It would seem logical therefore to assume an Indian rather than Atlantic Ocean origin for the King Island fish. As Munro does not credit the species to the Ceylon or New Guinea lists (1955 and 1967 respectively), the King Island specimen probably originated in the Southern Indian Ocean and was carried across on the west wind drift current. Sverdrup, Johnson and Fleming (1942) illustrate the course of this current as following an isothermal line linking the southern tip of Africa and the Southern Australian coast and Bass Strait. They mention that in winter this current continues in part towards the Pacific along the Southern Australian coast, but during summer the current bends north before reaching the Australian continent.

The fact that the King Island fish was found on a west coast beach in winter would support the hypothesis that it followed a current of more or less constant temperature eastwards to Australia. Although this could involve a distance of 7,000 miles or more it is not impossible when some of the peculiar characteristics of the fish are examined. Despite the fact that it is a feeble swimmer they are known for their ability to inflate the body with air and drift belly upwards with ocean currents (Smith, 1950). Like most of the other members of the order Tetraodontoidea the flesh is presumably toxic and protected by a tough, leathery skin rendering the fish almost immune from attack by other animals.

The specimen has been placed in the Tasmanian Museum ichthyological collection, registration number D934.

ACKNOWLEDGMENTS

The fish was obtained for the museum by Mr D. C. Wolfe, Fisheries Division, Department of Agriculture, Hobart. I am grateful to Dr R. McIntosh for a radiograph of the specimen.

REFERENCES

MUNRO, I. S. R., 1955.—The Marine and Freshwater Fishes of Ceylon. Department of External Affairs, Canberra.

————, 1967.—The Fishes of New Guinea. Department of Agriculture, Stock and Fisheries, Port Moresby, New Guinea.

RAMALHO, A., 1931.—*Lagocephalus lagocephalus*. Conseil Int. Expl. Mer, Faune Ichthyol. Antlantique Nord, Species No. 406.

SMITH, J. L. B., 1949.—The Sea Fishes of Southern Africa. Central News Agency, South Africa.

SVERDRUP, H. U., JOHNSON, M. W. & FLEMING, R. H., 1942.—The Oceans. Prentice-Hall, Inc.

TEMPLEMAN, W., 1962.—Record of the Oceanic Puffer, *Lagocephalus lagocephalus* (L.), Family Tetraodontidae, from Newfoundland. Jour. Fisheries Res. Board, Canada V 19, No. 5, pp. 811-814.

COMPARISON OF MEASUREMENTS OF THE KING ISLAND AND NEWFOUNDLAND SPECIMENS OF *Lagocephalus lagocephalus*

	King Island	*Newfoundland*
Length (Snout—mid caudal fork)	56.5 cm	60.2 cm
Standard length	51.3 cm	53.0 cm
Snout—tip of caudal (upper)	58.3 cm	62.8 cm
Snout—tip of caudal (lower)	60.8 cm	64.5 cm
Head (Snout—posterior border operculum)	14.6 cm	15.8 cm
Snout—Anterior border eye	6.4 cm	6.7 cm
Snout—Mid cloaca	35.0 cm	37.3 cm
Snout—Dorsal origin	36.7 cm	38.5 cm
Snout—Anal origin	38.3 cm	39.9 cm
Dorsal fin, length 1st ray (longest)	8.0 cm	9.6 cm
Caudal fin, length lower ray (longest)	11.1 cm	12.5 cm
Gill slit height (vertical)	3.2 cm	4.5 cm
Longitudinal diameter eyeball	2.0 cm	2.0 cm
Fin rays:—		
Dorsal	14+	15+
Anal	13	14
Left Pectoral	15	15
Right Pectoral	15+	16
Vertebrae	17	17

Plate 1.—*Lagocephalus lagocephalus* from King Island, Bass Strait.

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NOTES ON THE DISCOVERY OF ABORIGINAL REMAINS AT MOUNT CAMERON WEST TASMANIA

By

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(With one plate)

ABSTRACT

The recent discovery of an incomplete skeleton initially identified as that of a Tasmanian aboriginal adds to the limited number of osteological remains of the extinct race.

INTRODUCTION

During the exploration and early settlement of Tasmania, scientific interest in the Tasmanian aboriginal was restricted in the main to mere description of incidental contact. The development of a more systematic approach to an understanding of this primitive people coincided with the extinction of the race. Present research is thus dependent upon such skeletal remains as have been preserved in collections or which may from time to time be uncovered in the field.

LOCATION

The present find was made in a large midden area situated on the immediate south of Mount Cameron West, an imposing diabase headland projecting into the Indian Ocean. The surrounding area is rich in aboriginal remains, including the aboriginal carvings two miles to the north of Mount Cameron West. Permanent freshwater streams, plentiful supplies of shell fish and native animals made the area attractive to aboriginal settlement. The midden site is contained within one of several large parabolic dunes in the area and appears to have been, prior to deflation, an area protected from the westerlies by a line of sand dunes.

The distribution of refuse heaps in the 'blow-out', which consist mainly of small mussel, haliotis and turbo shells with a scattering of marsupial bones and artifact material, shows the location was one favoured by the aborigines.

The remains were found near the top of a low conical midden to the north of the site. The body appears to have lain with the head directed to the south in a full prone position. The cranium, consisting of three large segments and several smaller pieces, was separated by several inches from the partially exposed maxilla and mandible. Sections of long bones were also partly visible, the arm bones on the right side lying parallel to the body but those of the left limb exhibiting some flexing. Both legs appear to have been fully extended together. Bone fragments were observed in the upper part of the body and up to 5 feet away on the down slope of the midden. Blackened pieces of thin tabular bone-like material were found in the pelvic region.

Initial observation of the maxilla and mandible showed some fragmentation, apparently through natural weathering processes. Dentition appeared to be complete. Most teeth were in situ, the flat surface of the molars and lack of structural defect being readily noted.

Excavation and removal of the remains was carried out by Dr W. Bryden and Mr A. Dartnall of the Tasmanian Museum. Digging and screening of the immediate area revealed more bone remains; however none were found more than 6 inches below the surface. Long bones tended to display decay and weathering of upper and lower ends. The shaft of the left femur was broken in two parts towards the centre. No evidence of bones from the vertebral column was found. The flat bones were found to be extremely friable and moist. Initial work on the reconstruction of the cranium indicates that the greater part of the bones were recovered.

The excavated zone consisted of weathering shell material interspersed with sand and a half-dozen flints of inferior quality which did not appear to have been systematically placed. Two flat circular stones of approximately 8 inches diameter were found at the foot of the remains. They were similar to others found in the area.

An interesting note is made of the mobility of sand in the area. The introduction of grazing and subsequent removal of much of the native vegetation cover provides a plentiful supply of loose sand. Prevailing winds have built parabolic dune forms which continue to migrate inland. The finding, within the 'blow-out' portion of the dune, was made in the lee of a mound which had recently been exposed to strong easterly air movement. Prior to excavation on the third day (following discovery) the recurrence of westerly winds had reversed the sand flow to the dominant direction almost covering the remains. Thus repeated exposure and coverage might account for the poor state of preservation of the skeleton.

It might be inferred that little attempt was made by other aboriginals to dispose of the body in a traditional way. From Robinson's writings on the native inhabitants of the area it would appear

that the dead were promptly disposed of through the building of a ceremonial pyre. There is little evidence to suggest the possibility of flexed burial, or the wrapping or preserving of the remains as tokens—in particular the mandible. So one might conclude, taking into account the youthfulness of the specimen, that death was possibly due to trauma or disease.

The remains mentioned in this paper are now deposited in the Tasmanian Museum.

References

Crowther, W. L.—On Two Tasmanian Crania. *Pap. Proc. Roy. Soc. Tasm.*, 1929, pp. 123-127.

————————Notes on the Habits of the Extinct Tasmanian Race. *Pap. Proc. Roy. Soc. Tasm.*, 1933, pp. 22-25.

Crowther, W. L.—On the Discovery of Tasmanian Aboriginal Remains at Mount Dromedary, Tasmania. *Pap. Proc. Roy. Soc. Tasm.*, 1938, pp. 209-211.

———————— & Lord, C. E.—A Descriptive Catalogue of the Osteological Specimens Relating to the Tasmanian Aborigines Contained in the Tasmanian Museum, *Pap. Proc. Roy. Soc. Tasm.*, 1920, pp. 137-152.

Ling, R. H.—The Aborigines of Tasmania, King, Halifax, 1899, 2nd ed.

Meston, A. L.—Aboriginal Rock Carvings in Tasmania, Part II, *Pap. Proc. Roy. Soc. Tasm.*, 1932, pp. 1-6.

Plomley, N. J. B., Ed.—*Friendly Mission*, Tasmanian Historical Research Association, 1966, pp. 636-662.

Peron, F. & Freycinet, L.—*Voyage de Decouverte aux Terres Australes*, 2 vols. Paris. 1807-1816.

Scott, H. H. & McClinton, R.—A Note on the Burial Customs of the Tasmanian Aborigines, *Pap. Proc. Roy. Soc. Tasm.*, 1923, pp. 45-46.

Plate—Fragments of cranium, Mt Cameron West.

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THE CONFORMABLE TIN BEARING PYRRHOTITE-PYRITE 'SILLS' AT RENISON BELL, TASMANIA: MINERALOGY, RELATIONSHIPS, GENESIS[1]

By

Patrick Arthur Hill and Simon John Haynes

The pyrrhotite-pyrite lodes and sills of Renison Bell have been described by Gilfillan (1965) and Solomon (1965), and the regional geology by Blisset (1962). In 1961 Hill collected fifty drill-core samples, spaced at 2 to 10-foot intervals, from DDHs 48 and 60 (for localities see Gilfillan, 1965). These samples have now been studied in detail (drill logs in Hill and Green, 1962). This account is based on the information obtained from these samples.

DDH 48 cuts one 25-ft sill of pyrrhotite. DDH 60 cuts two: the upper 57 ft thick, the lower 5 ft thick. The upper has a 7-ft layer of pyrite near the base, the lower a 1.5-ft layer of pyrite.

The percentages of the 'economic' minerals were estimated optically, sample by sample. Grain sizes were measured with a micrometer eyepiece calibrated against a graduated graticule.

The economic minerals consist of cassiterite, pyrite, pyrrhotite, arsenopyrite, sphalerite, galena, and chalcopyrite. Galena and sphalerite increase in amount with depth but chalcopyrite decreases. Arsenopyrite is sporadically distributed. It is restricted to the upper parts of the sills and is minor in DDH 48 and more dominant in DDH 60. Wolframite, stannite, and magnetite are minor constituents.

The cassiterite is erratically distributed. Most of it is fine-grained and embedded in quartz, pyrrhotite, or carbonate. The crystals tend to be euhedral in massive carbonate and in quartz but subhedral in vein carbonate and in pyrrhotite. High assay values for tin are usually indicative of large crystals, rather than any increase in the number of crystals.

The paragenesis of the sills is:

Stage 1 Pre-existing magnetite, pyrite and carbonate

Stage 2 Quartz - apatite - tourmaline - wolframite - cassiterite - carbonate

Stage 3A Arsenopyrite

Stage 3B Pyrite - carbonate

Stage 4 Pyrrhotite - chalcopyrite - sphalerite - stannite - carbonate

Stage 5 Veins of quartz - cassiterite - wolframite - carbonate

Stage 6 Veinlets of quartz - pyrrhotite - chalcopyrite - sphalerite - carbonate

Stage 7 Veins and boxworks of carbonate - chlorite - chalcopyrite - pyrite - marcasite?

Stage 8 Supergene marcasite.

The vertical distribution of monoclinic and hexagonal pyrrhotite was determined by etching thirty-six polished sections with a saturated solution of chromic acid (Arnold, 1966). The alternative method (Cowan, 1968) using ammonium dichromate in 15% HCl was found to be unreliable.

From the pyrrhotite intergrowths that appeared, fifteen scratch samples were removed and X-rayed in a powder camera. Using the split and single 102 reflections both the monoclinic and the lower temperature hexagonal pyrrhotite were distinguishable. With one exception, the dark etched areas were found to be monoclinic, the light, hexagonal. Only three of the hexagonal patterns were clear enough to be matched with the 2A 5C hexagonal pyrrhotites of Carpenter and Desborough (1964).

The intergrowths revealed by the etching and confirmed by X-rays, consist of patches and lamellae. In general, monoclinic pyrrhotites contain patches of hexagonal whereas hexagonal pyrrhotites contain only discrete lamellae of monoclinic. Where hexagonal and monoclinic patches occur together they appear to be replacing one another. Both the monoclinic and the hexagonal lamellae appear to be crystallographically oriented within their host pyrrhotites.

In DDH 48, monoclinic pyrrhotite is dominant in the stringers above the main sill. (The possibility that some of the magnetite in the pyroclastics above the sill may have been formed by the oxidation of pyrrhotite cannot be completely eliminated.) Monoclinic pyrrhotite is also concentrated at the top and bottom of the sill, intergrown with lamellae and patches of hexagonal pyrrhotite. In the centre of the sill, monoclinic pyrrhotite is only slightly more abundant than hexagonal and the intergrowths consist solely of hexagonal lamellae.

In DDH 60, the monoclinic phase increases with depth. It is dominant (80%-100%) in the lower sill. It is dominant also in the upper sill below the

[1] The title of an unpublished M.Sc. thesis by Simon John Haynes (Carleton University, Ottawa, Canada, 1969, 143 pp.) from which thesis this paper has been abstracted.

pyrite band (100%) and in the pyrite band itself (50%-95%). Above the pyrite band, the hexagonal phase becomes dominant, reaching 60%-80% at the top of the sill. A direct relationship thus exists in this drillhole between monoclinic pyrrhotite and pyrite.

The distribution of the two phases of pyrrhotite must be considered fully in any future geophysical interpretation of Renison Bell for monoclinic pyrrhotite is ferromagnetic, hexagonal, paramagnetic. The difference in magnetic susceptibility could lead to a more effective recovery of the cassiterite if it could be shown that the cassiterite was concentrated more in one phase than in the other.

To check the percentages of hexagonal pyrrhotite as determined in etched sections, fourteen 'bulk' samples of pyrrhotite were X-rayed by the diffractometer method of Graham (1966). Except for two samples (434, 436) midway up the upper sill of DDH 60, the percentages of hexagonal pyrrhotite could be correlated to within ±15%. Both Arnold (1966) and Graham (1966) have shown that bulk samples from the same hand specimen can vary greatly in their monoclinic to hexagonal ratios.

The distribution of the pyrrhotite phases relative to the pyrite band in DDH 60 suggests that the bulk composition of pyrrhotite of Paragenetic Stage 4 approached equilibrium with the pyrite of Stages 1 and 3. The distribution of the pyrrhotite phases can be explained by a cooling history which started either above or below the β transformation of pyrrhotite (about 310° C) and which later was modified by low temperature reactions, and by variations in the sulphur fugacity. As the late pyrrhotite (Stage 6) which cuts earlier massive pyrrhotite (Stage 4) is richer in monoclinic pyrrhotite, and therefore in sulphur, a late S-rich 'front' may have advanced laterally along the sills.

To determine the temperature of formation six geothermometers were considered. Serious consideration could however be given to only three: the quartz decrepitation, the system Fe-As-S, and the system Cu-Fe-S.

The decrepitation of the quartz indicates a temperature of 350°±50° C for the formation of the cassiterite, a temperature which is questionable because of the unknown amounts of CO_2 present at the time. Of the Fe-As-S, the arsenopyrite and pyrite texturally (Stage 3) appear to have formed a stable assemblage and were thus probably emplaced below 491° C. However as the quartz inclusions are unruptured the arsenopyrite-pyrite was probably deposited below 350°±50° C.

Of the system Cu-Fe-S, the main phase of sulphide metallisation (pyrrhotite-chalcopyrite-sphalerite of Stage 4) probably took place below 334° C although it is not known whether the pyrrhotite had reached a full equilibrium with the earlier pyrite.

As to origin, no evidence *exists in the samples studied* that the sills might be syngenetic. The decrepitation of the quartz; the ratios of the sulphur isotopes; the similarity of the Co:Ni ratios of the pyrites with those at Mt Bischoff (Groves and Solomon, 1964); and the high content of manganese in the sphalerites suggest that the sills had, at least in the latter part of their history, a predominantly hydrothermal-magmatic origin and were derived from gases or fluids rising up the fissure lodes, spreading out laterally, and selectively and effectively replacing the carbonate horizons, preserving in the pyrrhotite the original stylolites. The pre-existing ankeritic carbonates were remobilised, locally enriched in manganese and iron, and redeposited in veins and masses.

References

Arnold, R. G., 1966.—Mixtures of hexagonal and monoclinic pyrrhotite and the measurement of the metal content of pyrrhotite by X-ray diffraction. *Amer. Mineralogist*, 51, pp. 1221-1227.

Blisset, A. H., 1962.—Explanatory report, 1-mile Geological Map Series, Zeehan, Dept Mines, Tasmania.

Carpenter, R. H. & Desborough, G. A., 1964.—Range in solid solution and structure of naturally occurring troilite and pyrrhotite. *Amer. Mineralogist*, 49, pp. 1350-1363.

Cowan, J. C., 1968.—Geology of the Strathcona ore deposit. *Canadian Min. and Metall.*, 61, pp. 38-54.

Graham, A. R., 1966.—Quantitative determination of monoclinic and hexagonal pyrrhotites by X-ray diffraction. Mineralogical Assoc., Canada, Halifax Meeting (Preprint) 22 pp.

Gilfillan, J. F., 1965.—Tin ore deposits of Renison Bell, in *Geology of Aust. Ore Deposits*, 8th Commonwealth Min. and Metall. Congr., pp. 495-496.

Grooves, D. I. & Solomon, M., 1964.—Geology of the Mt Bischoff district. *Pap. Proc. Roy. Soc. Tasm.*, 98, pp. 1-22.

Haynes, S. J., 1969.—The conformable tin bearing pyrrhotite-pyrite 'sills' at Renison Bell, Tasmania: Mineralogy, relationships, genesis: Unpublished M.Sc. thesis, Carleton University, Ottawa, Canada, 143 pp.

Hill, P. A. & Green, G., 1962.—Thermoelectricity and resistivity of pyrite from Renison Bell and Mt Bischoff, Tasmania. *Econ. Geology.*, 57, pp. 579-586.

Solomon, M., 1965.—Geology and Mineralisation of Tasmania, in *Geology of Aust. Ore Deposits*, 8th Commonwealth Min. and Metall. Congr., pp. 464-476.

Papers and Proceedings of the Royal Society of Tasmania, Volume 104

[*Manuscript received 16 October 1969*

A NOTE ON ABORIGINAL PETROGLYPHS AT DEVONPORT, TASMANIA

By

Peter C. Sims

Devonport, Tasmania

(Communicated by Dr W. Bryden)

(With one figure)

Over the years there have been various descriptions of Tasmanian aboriginal Rock Art. However this information is by no means complete and many of Tasmania's twelve known sites have not been fully investigated or documented with the exception of Mt Cameron West.

Devonport Bluff

In 1931 the Royal Society of Tasmania published a paper together with plates by Mr A. L. Meston on the Devonport Rock Engravings. To date, many of the motifs described by Meston have not been located due to several factors; one being that no detailed description of the location of each motif has been recorded and secondly roads, weeds, natural regrowth and weathering have caused the temporary masking or in some cases the complete disappearance of many examples.

The most significant find to date is an example depicting the outline of an emu (see figure). This motif was not recorded by Meston but mention is made of other petroglyphs resembling a bird's head, and a coiled snake. Once these are located and recorded it should end the doubts held by some people on the authenticity of the Devonport Engravings.

The petroglyph depicting the emu, a bird now extinct in Tasmania, is engraved on a horizontal rock face in an area of exposed broken outcrops of rock slabs 20 feet x 55 feet. Other designs appear on adjacent rock faces and there have been twelve motifs located so far on this particular area. The position from the Lighthouse at the 'Bluff' which is a State Permanent Mark S.P.M. 2680 is 250 feet at 210° compass bearing.

The depth of the incision varies, the left leg of the emu is 12 mm deep, while the depth of other parts of the motif vary from 2 mm at the head to 5 mm for the right leg.

The overall dimensions of the motif are 37.5 cm x 15 cm.

The interesting figure below the emu motif is deliberate and this varies in depth from a general depression at the arrowhead representation to 12 mm at the deepest point. It is interesting to note that Meston reported that the motifs did not coincide with the natural cracks in the rocks and this fact is supported by the author.

In the meantime recording is continuing at Devonport's Bluff site which is very rich in the variety of petroglyphs. It is anticipated that a full account will be published later on the material examined.

ERRATA

VOLUME 102, PART II

N. J. B. PLOMLEY

Page 50, L.H. column, paragraph 4, line 11—FOR 'January 1938' READ 'January 1838'.

Page 52, R.H. column, quotation 'Dumoutier', line 6—FOR 'terre de Diemen' READ 'terre de Van Diemen'.

Page 53, L.H. column, item 1, line 4—FOR 'of September 1835' READ 'of 18 September 1835'.

Same page, R.H. column, item 4, second last line—FOR 'BENGER' READ 'BANGER'.

Same page, R.H. column, quotation from 'Mercury' (Hobart), paragraph 1, line 5—FOR 'Dutterreau' READ 'Duterreau'.

Page 54, R.H. column, paragraph 3, last line—FOR 'Marray' READ 'Murray'.

VOLUME 103

E. O. G. SCOTT—'Description of *Brachaluteres wolfei* sp. nov., etc.'—

Page 35, column 1, line 12 FOR 'Dixon, 1939' READ 'Dixon, 1969'.

Page 43, column 2, line 10 FOR 'Harrison, A. J. & Scott, E. O. G., 1929' READ 'Harrison, A. J. & Scott, E. O. G., 1969'.

A. J. DARTNALL—'New Zealand Sea Stars in Tasmania'—

Page 55, column 2, line 13—FOR 33 READ 32.

Same page, same column, line 55 FOR '*Allostichaster Polyplax* (Muller and Troschel)' READ '*Allostichaster regularis* H. L. Clark, 1928'.

N. J. B. PLOMLEY—'The Tasmanian Journal of Natural Science'—

Page 14, R.H. column, Vol. I, no. I—FOR 'September 10' READ '10 September 1841'.

Same page, same column, Vol. II no. IX—FOR '*T.T. Courier*' READ '*H.T. Courier*'.

PAPERS AND PROCEEDINGS

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The Royal Society of Tasmania

Volume 105

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Royal Society of Tasmania

Papers and Proceedings Vol. 105

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Royal Society of Tasmania

Annual Report for the Year 1970

The Council has the honour to present to members the following report on the activities of the Society during 1970.

PAPERS AND PROCEEDINGS.

Volume 104 of the Papers and Proceedings was printed and distributed. It is of interest to note that this volume is distributed to countries in various parts of the world, in all continents. Many exchanges are maintained, and in return we receive publications in the various disciplines. This method of exchange is of inestimable value to the Society's library as, through it, many of our valuable holdings have been built up over the years. It is interesting to note that in some subjects our holdings provide the most complete references in Australia, but it may be pertinent to add that each year more and more scientific institutions are notifying us that, because of increased costs, the free exchange can no longer continue. The Society has a real problem here, for if we are to continue some of the series we have had for scores of years, we will have to purchase. As is well known, our funds are limited, so some day not too far distant the Society as a whole may have to consider whether to continue the library series or to call a halt to some of the activities of the Society, or to increase subscriptions.

THE LIBRARY.

During the year the library was moved to the new quarters in the University. The accommodation is provided in secure quarters, and removes many of the hazards which faced it in the room in the museum building.

The shelving in the old library was removed and the room painted. It is proposed to continue to use the room for general meetings. The library has been associated with the Tasmanian Museum since 1863, when the Society moved into the building which is now the Museum and which was built through the instigation of the Royal Society itself. The Trustees of the Museum, and the Council of the Society expressed regret that the close association built up over the years was to be broken, but both groups are pleased to note that some real association will remain.

Six hundred volumes, chiefly journals, were added to the library during the year.

ANNUAL MEETING.

The Annual Meeting was held in March when the Annual Report and the Statements of Receipts and Payments were adopted.

At that meeting the vacant position of Vice-President was filled by the election of Mr E C. Gifford, the positions of Councillors by the election of Dr D. Martin and Mr A. R. Neilson. The positions of Honorary Treasurer, Honorary Auditor and Honorary Secretary were filled by the re-election of those who held those positions the previous year.

LECTURES.

During the year another series of very interesting lectures was provided for members. It is of considerable benefit for members to be enabled to hear dissertations by specialists in the various fields of science and arts, and all are grateful to those people who are kind enough to accept our invitation to lecture.

The following lectures were given during the year:—

April: 'An Expedition across Central Australia in search of Aboriginal Rock Engravings.' By Mr J. B. Thwaites, Hobart.

May: 'Soils and Apple Trees.' By Mr K. D. Nichols, Division of Soils, C.S.I.R.O., Hobart.

June: 'Horticulture in an Industrial Nation.' By Professor G. Bunemann, Director of the Institute for Horticulture, Technical University of West Berlin.

July: 'Some Notes on the Life and Times of Captain James Kelly.' By Mr E. R. Pretyman, Hobart.

August: 'Charles Darwin in Hobart Town and Geological Work in Van Diemen's Land.' By Mr M. R. Banks, Department of Geology, University of Tasmania.

September: 'Man's Place in the Limitless Abyss of Space/Time'. By Dr John Morris, Launceston.

October: 'The Early Development of the East Coast (Cape Portland to Bicheno)'. By the Honourable Mr Justice Crawford, Launceston.

November: 'Geographical Contributions to Medicine'. By Dr N. D. McGlashan, Department of Geography, University of Tasmania.

ROYAL SOCIETY MEDAL.

The Council decided to recognise the work done by Dr D. L. Serventy in his researches on the Tasmanian Mutton Bird. It was agreed that Dr Serventy be invited to give a special lecture, and that he be awarded the Royal Society Medal. This was done at a special meeting held in the Town Hall, Hobart, on the 8th December last, when His Excellency the Governor of Tasmania, who is President of the Society, presented the medal to Dr Serventy.

NORTHERN BRANCH.

The Branch continued to act in the Northern part of the State and an interesting series of lectures was arranged.

MEMBERSHIP.

During the year the membership reached 552, a decline of 17. There are 4 Honorary Life Members and the membership of the Northern Branch totalled 228.

ACKNOWLEDGMENTS.

The Council is most grateful for the help so generously given by many individuals and organisations, and particularly to the Government of Tasmania, the University of Tasmania, The Trustees of the Tasmania Museum and Art Gallery, the Queen Victoria Museum and Art Gallery, the Press, the Radio, and to the many individuals who have assisted during the year.

Royal Society of Tasmania—Northern Branch

Annual Report for the Year 1970

After elections at the Annual General Meeting of the Northern Branch on 5th March, 1970, the Branch Council comprised:

Chairman—Mr J. N. Gee.

Vice-Chairman—Mr D. Walter.

Honorary Secretary and Treasurer—Mr W. F. Ellis.

Past Chairman—Dr J. C. H. Morris.

Council—Mr H. W. Askeland, Mr R. S. Smith, Mrs M. Cameron, Mr Justice Crawford, Mr K. E. J. Robinson.

Honorary Auditor—Mr H. C. A. Pitt.

Mr Gee and Dr Morris were appointed delegates of the Northern Branch to the Council of the Society.

MEMBERSHIP.

On 31st December, 1970 there were 228 members of the Northern Branch.

ACTIVITIES.

Eleven general meetings were arranged, at which the following lectures were delivered:

6 February, 1970: 'An Introduction to Australian Butterflies', by Mr L. E. Couchman.

5 March, 1970: 'Evolution—Man's Place in the Limitless Abyss of Space/Time', by Dr J. C. H. Morris.

3 April, 1970: 'The History of Tamar Shipping', by Mr G. W. Cox.

1 May, 1970: 'An Expedition Across Central Australia in Search of Aboriginal Rock Carvings', by Mr J. B. Thwaites.

5 June, 1970: 'The History of the Launceston Artillery', by Hon. Lieut. Colonel G. H. Crawford.

3 July, 1970: 'Medieval Church Architecture', by Mr D. Walter.

7 August, 1970: 'Oceanography in Australia, with special reference to mineral resources', by Mr L. C. Noakes.

4 September, 1970: 'Australia, New Guinea and Melanesia in the current revolution in concepts of the evolution of the earth', by Professor S. W. Carey.

9 October, 1970: 'Charles Darwin in Hobart Town and Geological Work in Van Diemen's Land', by Mr M. R. Banks.

6 November, 1970: 'Game Reserves and Nature Conservation in South Africa', by Mr T. G. Cashion.

4 December, 1970: 'Members lecturettes—

'On the Milford Track, New Zealand', by Mr J. W. Twycross.

'Life 100 Years Ago', by Mr G. H. Stancombe.

'On the Thames', by Miss J. Craig.

'Views of Launceston, 1890', by Mr R. S. Smith.

'Conservation and Environmental Control' by Mr S. V. Tilley.

'Maria Island', by Mr N. R. Harvey.

'Fluorescent', by Mr J. J. Allchin.

An excursion to the Mersey Forth Hydro-Electric Semaphore Stations was held on 19 April, 1970 and, betweeen 28 and 29 November, the study tour of the East Coast was extended to the areas around Swansea.

An excursion to the Mersey-Forth Hydro-Electric System was arranged for 29 August, but severe floods necessitated its cancellation.

The Branch Council met five times during the year.

The Committee led by Mr Stancombe surveying burial grounds for historical information prior to 1900 has continued its work. Catalogues of headstones in twelve more cemeteries were completed.

Work has continued with the monument to commemorate Matthew Flinders. Approval has been given to occupy a site overlooking the Tamar River at Batman Bridge and the design of the memorial is progressing.

The Branch Council has become deeply concerned about increases in expenditure for the activities of the Branch, for which no provision exists in the present means of allocating funds. Submissions have been presented to the Council of the Society for discussion but, as yet, no progress has been made in this vital matter.

[*Manuscript received 27th August, 1970*

A CATALOGUE OF THE TYPE MATERIAL (FISHES) IN THE TASMANIAN MUSEUM

by

A. P. Andrews,
Tasmanian Museum

ABSTRACT

A total of twenty three type and cotype specimens is listed. Both old and recent registration numbers are included and recent alterations in taxonomy.

INTRODUCTION

The study of Tasmanian Ichthyology which extends back over almost two hundred years was initiated by the early explorers. The material collected by them was taken back to Europe for description, the types and figured specimens usually being deposited in European institutions. With the establishment of the Royal Society of Tasmania in 1843 a venue for local publications and a repository for specimens became available.

When, in 1885 the Museum and Botanic Gardens were handed over to the State, research work of fishes was well established. Writers such as W. Saville-Kent, R. M. Johnston and Alex Morton had all made contributions and in 1891 R. M. Johnston published his list of all the then known species.

In 1913 the Commonwealth Government presented a large collection of specimens collected by the F.I.S. *Endeavour* during the years 1909 to 1914. Included were types described by A. R. McCulloch. During the subsequent years the type collection has been increased in size and many of the species described earlier have been put into synonomy. The purpose of the present work is to bring the list up to date regarding recent additions and taxonomic changes.

NOTES

The *Endeavour* material was originally registered in the Australian Museum, Sydney and the original numbers are included together with current Tasmanian Museum numbers. Old Tasmanian Museum numbers are prefixed by the letters 'TM' or 'D'. Current Tasmanian Museum numbers are prefixed by the letter 'D'.

Class *ELASMOBRANCHII*
Order **SQUALIFORMES**
Family SQUALIDAE
Genus **CENTRINA** Cuvier 1816
Centrina bruniensis Ogilby, 1893

Rec. Aust. Mus. II, 5, Sept. 1893, p. 62.
= *Oxynotus bruniensis* (Ogilby), 1893.
Holotype: D154/13139, Mounted skin.

Locality: Collected on the shore of Bruny Island, Tasmania. Dead and dried out but in a fair state of preservation.

Note: Old Reg. No. TM 3079.

Class *TELEOSTOMI*
Order **CLUPEIFORMES**
Family STERNOPTYCHIDAE
Genus **POLYIPNUS** Gunther, 1887
Polyipnus tridentifer McCulloch, 1914.

Biol. Res. *Endeavour*, II, 3, July 3, 1914, p. 87.
Cotypes (5) D151/13032. Spirit specimens.
Locality: Great Australian Bight, Long. 129°28'E. F.I.S. *Endeavour* 350-450 fathoms, 14 May 1913.
Note: Old Reg. No. D37.

Order **GALAXIIFORMES**
Family GALAXIIDAE
Genus **PARAGALAXIAS** Scott, 1935
Paragalaxias shannonensis Scott, 1935.

Pap. and Proc. Roy. Soc. Tasmania 1934 (1935) p. 41.
Paratypes: D1/180. Spirit specimen.
D996 „ „
Locality: Shannon River, below Miena dam, Great Lake Tasmania. 3 Dec. 1933.
Note: The second paratype (D996) was originally lodged in the Zoology Dept, University of Tasmania and was transferred to the Tasmanian Museum in 1969.

Genus **GALAXIAS** Cuvier, 1816
Galaxias parvus Frankenberg, 1968

Aust. Zool. Vol. XIV, Part 3, 1968, p. 268. pl. XIV-XV.
Holotype: D940. Spirit specimen.
Locality: Lake Pedder, south west Tasmania, from a pond on the east bank 1 - 3 Feb. 1967.
Galaxias pedderensis Frankenberg, 1968

Aust. Zool. Vol. XIV, part 3, 1968, p. 268. pl. XIV-XV.
Holotype: D941. Spirit specimen.
Locality: Lake Pedder, south west Tasmania, from mouth of inflowing stream from Lake Maria. 1 Feb. 1967.

Order **MACRURIFORMES**
Family MACRURIDAE
Genus **CORYPHAENOIDES** Hector, 1871
Coryphaenoides tasmaniae Johnston, 1883

Pap. and Proc. Roy. Soc. Tasmania 1882 (1883), p. 143.
= *Macruronus novaezelandiae* (Hector), 1871.
Holotype: D144/13025. Spirit specimen.
Cotypes (4): D31/497. Spirit specimens.
Locality: Kangaroo Bluff, Tasmania.
Note: In his description, Johnston mentions that the species had been known from the west coast and entered the Derwent occasionally but gives no dates for the collections of the material.

D144/13025 = Old Reg. No. TM5785.
D31/497 = Old Reg. No. TM5184.

Order **GADIFORMES**
Family MORIDAE
Genus **LEPIDION** Swainson 1838

Lepidion microcephalus Cowper, 1956
Pacific Science 10 : p. 407-409.
Holotype: D160/13225. Spirit specimen.

Locality: East coast, Tasmania, 12 miles east of Schouten Island, 400-420 fathoms 15 Feb. 1953.

Order **ZEIFORMES**
Family ZEIDAE
Genus **ALLOCYTTUS** McCulloch, 1914

Allocyttus verrucosus Gilchrist *var. propinquus* McCulloch, 1914
Biol. Res. *Endeavour,* II, 3, July 3, 1914, p. 116.
= *Allocyttus verrucosus* (Gilchrist), 1928.
Cotype: D146/13027. Spirit specimen.

Locality: Great Australian Bight 129°28'E, 350-450 fathoms, 14 May 1913, F.I.S. *Endeavour.*

Note: Old Reg. No. D32, Aust. Mus. No. E3282.

Order **BERYCIFORMES**
Family BERYCIDAE
Genus **AUSTROBERYX** McCulloch, 1911

Austroberyx brevis (?) McCulloch, 1911
Biol. Res. *Endeavour* I, Dec. 22, 1911, p. 39.
= *Centroberyx affinis* (Gunther), 1859.
Cotype: D139/13020. Spirit specimen.

Locality: Flinders Island, Bass Strait, 37 fathoms, 28 Aug. 1911, F.I.S. *Endeavour.*

Note: Aust. Mus. No. E962. Specimen labelled 'Austroberyx brevis, McCull, 1911, Cotype gen. et sp.' McCulloch makes no reference to this species in his description.

Family TRACHICHTHYIDAE
Genus **HOPLOSTETHUS** Cuv. & Val., 1829

Hoplostethus mediterraneus. C. & V. var. latus McCulloch, 1914
Biol. Res. *Endeavour* II, 3, July 3, 1914, p. 97.
= *Hoplostethus mediterraneus* Cuv.‡ 1829.
Cotype: D140/13021. Spirit specimen.

Locality: Great Australian Bight, west from Eucla 126-127 fathoms. F.I.S. *Endeavour.*

Note: Old Reg. No. D102 Aust. Mus. No. E2467.

Order **SYNGNATHIFORMES**
Family SYNGNATHIDAE
Genus **HISTOGAMPHELUS** McCulloch, 1914

Histogamphelus briggsii McCulloch, 1914
Aust. Zool. I, 1. June 13, 1914, p. 29.
Holotype: D141/13022. Spirit specimen.
Locality: Wineglass Bay, east coast Tasmania, 11 fathoms, E. A. Briggs, 13 April 1914.
Note: Old Reg. No. D79.

Family MACRORHAMPHOSIDAE
Genus **CENTRISCOPS** Gill, 1862

Centriscops cristatus (?) McCulloch, 1914
Biol. Res. *Endeavour II,* 3, July 3, 1914, p. 93.
= *Notopogon endeavouri* Mohr, 1937.
Cotypes (2): D145/13026. Spirit specimens.
Locality: Dredged in Bass Strait, F.I.S. *Endeavour.*
Note: Old Reg. No. D33. Aust. Mus. No. E2145.

Name apparently introduced in error for *C. humerosus* McCulloch, 1911 = *N. lilliei* Regan. (McCulloch 1914, p. 91).

Order **PERCIFORMES**
Sub-order **COTTOIDEI**
Family PLATYCEPHALIDAE
Genus **INSIDIATOR** Jordan & Snyder, 1900

Insidiator jugosus McCulloch, 1914
Biol. Res. *Endeavour II,* 3, July 3, 1914, p. 144.
Cotypes (2): D150/13031. Spirit specimens.
Locality: Queensland, seven miles off Hummocky Island, S7°E, 30 July, 1910. F.I.S. *Endeavour.*
Note: Old Reg. No. D36, Aust. Mus. No. E2688.

Sub-Order **PERCOIDEI**
Family CARANGIDAE
Genus **CARANX** Lacepede, 1802

Caranx humerosus McCulloch, 1915
Biol. Res. *Endeavour III,* 3, April 21, 1915, p. 137.
= *Carangoides humerosus* (McCulloch), 1915.
Cotypes (2): D138/13019. Spirit specimens.
Locality: Queensland, 11-14 miles N 59°W off Pine Peak, 24-26 fathoms 1 Aug. 1910, F.I.S. *Endeavour.*
Note: Old Reg. No. D100-101 Aust. Mus. No. E2821.

Family PEMPHERIDAE
Genus **PEMPHERIS** Cuvier, 1829

Pempheris elongata McCulloch, 1911
Biol. Res. *Endeavour I,* Dec. 22, 1911, p. 47.
= *Parapriacanthus elongatus* (McCulloch) 1911.
Cotype: D137/13018. Spirit specimen.
Locality: Flinders Island, Bass Strait 40 fathoms, 28 Aug. 1911. F.I.S. *Endeavour.*
Note: Aust. Mus. No. E. 470.

Family EMMELICHTHYIDAE
Genus **PLAGIOGENEION** Forbes, 1890

Plagiogeneion macrolepis McCulloch 1914
Biol. Res. *Endeavour* II, 3, July 3, 1914, p. 104.
Cotypes: D148/13029. Spirit specimen.
D149/13030 „ „
Locality: Great Australian Bight, 100-320 fathoms. F.I.S. *Endeavour.*

Sub-Order **GOBIOIDEI**
Family GOBIIDAE
Genus **GOBIUS** Linnaeus, 1758

Gobius hinsbyi Johnston, 1903.
Abstr. Proc. Roy. Soc. Tasmania, May 13, 1902 (1903), p. X *Nom. nud.*
= *Nesogobius hinsbyi* (McCulloch & Ogilby), 1919.
Holotype: D142/13023. Spirit specimen.
Locality: Derwent estuary, Tasmania.
Collected by Mr Geo. Hinsby.

Sub-Order **BLENNIOIDEI**
Family CLINIDAE
Genus **CLINUS** Cuvier, 1816

Clinus johnstoni Saville-Kent, 1886
Rept. Fish. Dept, Tasmania No. 37, 1886, p. 13.
Described in Pap. & Proc. Roy. Soc. Tasmania 1886 (1887), p. xxxiv & 121.
= *Petraites johnstoni* (Saville-Kent) 1886.
Holotype: D58 (Old. Reg.) Spirit (?) specimen.
Locality: Adventure Bay, Bruny Is., Tasmania.
Note: The specimen was recorded as missing in 1935 and has not subsequently been found.

Order **LOPHIIFORMES**

Family ANTENNARIIDAE

Genus **ANTENNARIUS** Cuvier, 1816

Antennarius mitchelli Morton, 1897

Pap. & Proc. Roy. Soc. Tasmania, 1896 (1897, p. xiv & 98.

= *Echinophryne mitchelli* (Morton) 1897.

Holotype: D136/13017. Spirit specimen.

Locality: Lisdillon, east coast Tasmania, Miss Mitchell, 1895.

Note: Old Reg. No. TM5163 & 3566.

Order **LABRIFORMES**

Family NEOODACIDAE

Genus **OLISTHOPS** Richardson, 1850

Olistherops brownii Johnston, 1884

Pap. & Proc. Roy. Soc. Tasmania, 1883 (1884), p. lviii & 193.

= *Olisthops cyanomelas* Richardson.

Holotype: D135/13016. Spirit specimen.

Locality: Table Cape, Tasmania (no date), Mr J. Brown.

Note: Old Reg. No. TM10932.

REFERENCES

COWPER, T. R., 1956—A New Gadiform Fish from the Continental Slope off South-eastern Australia. *Pacific Science,* **10,** p. 407.

FRANKENBERG, R., 1968—Two New Species of Galaxiid Fishes from the Lake Pedder Region of Southern Tasmania. *Aust. Zool. XIV,* **3,** p. 268.

JOHNSTON, R. M., 1883—General and critical observations on the fishes of Tasmania; with a classified catalogue of all the known species. *Pap. & Proc. Roy. Soc. Tasmania* 1882 (1883), p. 53.

————, 1884—Notice of recent additions to the list of Tasmanian fishes. *Pap. & Proc. Roy. Soc. Tasmania,* 1883 (1884), p. lviii & 193.

————, 1903: A New Fish. Abstract of Proceedings, May, 1902. *Pap. & Proc. Roy. Soc. Tasmania,* 1902 (1903) pX.

MCCULLOCH, A. R., 1911—Report on the Fishes obtained by the F.I.S. *Endeavour* on the Coasts of New South Wales, Victoria, South Australia, and Tasmania. *Biol. Res. Endeavour I,* Dec. 22, 1911. p. 39 & p. 47.

————, 1914—Notes on some Australian Pipefishes. *Aust. Zool. I,* **1,** June 13, 1914. p. 29.

————, 1914—Report on some Fishes obtained by the F.I.S. *Endeavour* on the coasts of Queensland, New South Wales, Victoria, Tasmania, South and South-western Australia. *Biol. Res. Endeavour, II,* **3,** July 3, 1914. p. 87, p. 93, p. 97, p. 104, p. 116, p. 144.

————, 1915—*Biol. Res. Endeavour III,* **3,** April *21,* 1915, p. 137.

MORTON, A., 1897—*Antennarius mitchelli sp. nov. Pap. & Proc. Roy. Soc. Tasmania,* 1896 (1897), p. xiv & 98.

OGILBY, J. D., 1893—Description of a New Shark from the Tasmanian Coast. *Rec. Aust. Mus. II,* **5,** Sept. 1893. p. 62.

SAVILLE-KENT, W., 1886—Rep. Fish Dept, Tasmania **37,** 1886. p. 13.

————, 1887—Observations on a suspected hybrid species of Trumpeter, and upon other rare Fish taken in Tasmanian waters. *Pap. & Proc. Roy. Soc. Tasmania.* 1886 (1887). p. xxxiv & 121.

SCOTT, E. O. G., 1935—On a New Genus of Fishes of the family Galaxiidae *Pap. & Proc. Roy. Soc. Tasmania,* 1934 (1935). p. 41

A DARWIN MANUSCRIPT ON HOBART TOWN

by

Maxwell R. Banks,
University of Tasmania

Read before the Society, 4th August, 1970

ABSTRACT

The collection of Darwin's papers in the Library of Cambridge University includes a 22-page manuscript on the Geology of Hobart Town. Consideration of the manuscript suggests that Darwin's collection of fossils described in 'Geological Observations' came from the Bundella Mudstone at Porter Hill, the Cascades Group near Barossa Road, Glenorchy, and the Malbina Formation at Eaglehawk Neck. The manuscript further demonstrates his assiduity and acuteness as a geological observer, and suggests a considerable fund of geological knowledge of Van Diemen's Land in 1836.

INTRODUCTION

During consideration of a manuscript by the late Edith Smith dealing with the fossil polyzoa described by Lonsdale in Darwin's 'Geological Observations' (1844), the question arose as to the most likely places from which Darwin had collected his specimens. In following this up, contact was made with the Librarian, Cambridge University. where Darwin's papers are lodged, and the Librarian made available a microfilm of a manuscript memorandum on the geology of Hobart Town. Because of the importance to palaeontological taxonomists of this memorandum in revealing Darwin's collecting spots and because of the additional light it throws on Darwin's activities while in the area as well as on his geological ability, the manuscript has been deciphered and is reproduced here with Darwin's original notations. Plate 1, a copy of p. 8 of his manuscript, is reproduced by permission of the Syndics of Cambridge University Library.

I would like to acknowledge the help of the staff of the State Archives, Morris Miller Library at the University of Tasmania, the Under-Librarian of Cambridge University Library, the Curator of the Darwin Collection at Down House, and Miss E. Geddes, Librarian to the Royal Society of Tasmania.

Mr R. F. Wise, British Museum of Natural History, kindly made available fragments of the matrix of some important Tasmanian fossils held therein and rubber moulds of some of these fossils. I would also like to acknowledge helpful criticism from Professor S. W. Carey, Mr D. E. Leaman and my wife.

Memo on Hobart Town by Charles Darwin,
transcribed by Maxwell R. & Doris M. Banks.
1836 February Hobart Town 837 (1

In the neighbourhood of Hobart town, two(i) *distinct formations occur, both accompanied by rocks of igneous origin, I will begin by the most modern of the two. In this formation the prevalent rock is white, fine grained Sandstone, composed of minute grains of Quartz*(ii) *with a little white cementing matter. Within the town it is associated, with reddish laminated Aluminous Sandstones, other ferruginous ones and some Clay Shales.*

On a hill close behind the town, there are strata of a very impure Coal, carbonaceous Shale, and white Sandstone banded with the finest lines, stained black, by a similar substance. Here such layers are penetrated (crossed out *is 'with all at a high angle and being disturbed'*) *by a great mass or dyke (a hundred yards wide) of a decomposing Greenstone; on one side the strata dip away at an angle of 60° or 70° and fragments*(iii) *of Porcelain rock and indurated sandstone, lying in the lines of junction, point out the effect of an igneous mass — on the other side, the confusion is even greater; layers of impure Coal, being now in a nearly vertical position:* A

Footnotes:

The following comments occur in the margin of the manuscript at the place indicated:

i. *'R.N. p. 120; Granite on E. coast* B

ii. *Examine flints in 'Flo' formation for Infusoria*

iii. *Dr Scot's paper on Van Diemen's Land Annals of Philosophy. June 1834.* C

Comments:

A. This probably refers to dolerite dyke which cuts and indurates the Upper Triassic succession between Clare St Oval and Waverley Ave, and is cut by Augusta Road at 516.25 E. 722 .55 N. The dimensions of the dyke and the lithology of the intruded rocks fit the description; the tilting of the strata is considerable but the vertical strata mentioned are no longer visible if this is the locality described. Another, less likely, possibility is that it refers to a Tertiary basaltic dyke which intrudes, bakes and disturbs the Triassic sediments which include carbonaceous siltstone at the top of Arthur St, West Hobart, in the eastern abutment of the former Crisp and Gunns Quarry (516.55 E. 720.9 N). However the width of this dyke is only 10 to 20 yards, not a hundred as stated by Darwin.

B. 'R.N.' refers to one of Darwin's notebooks so marked on front and back cover. Page 120 contains the pencilled comment 'Bailly talks of much granite on all East side of Van Diemen's Land' (Miss J. Dobson, Curator of Down House, pers. comm.) Bailly was one

of the naturalists with Baudin during his exploration of Van Diemen's Land in 1802 (Péron 1807).

C. Presumably a reference to a paper by the Rev. Archdeacon T. H. Scott in *Annals of Philosophy*, Vol. 7, p. 462 for June 1824. This very brief paper commented on the similarity in geology of 'New Holland' and 'Van Diemen's Land.' It noted the presence of rocks of the 'coal formation' at Hobart and Georgetown, of fossiliferous limestone between Hobart and New Norfolk and near Georgetown, of a rock like 'the Millstone Grit' and salt in the Midlands and 'elevated primitive ridges' on both sides of the Midlands valleys.

1836 February Hobart town 838 ('2
In the Government domain and in other places I saw the Sandstones and Greenstones abutting against each other in straight lines. In all parts of the hill, on D
which the town stands dykes of Trappean rock and those of aqueous origin alternately appear; and I am doubtful which E
class is most abundant—the Stratification in some places, as has been shown, is exceedingly disturbed and inclined strata generally are common; in many cases however, this is the result of the manner deposition, as has been described near Sydney, and hence the two classes are not easy to be distinguished. Following the coast down to the South of the town frequent patches of this formation are met with. I found a coarse ferruginous Sand- F
stone containing numerous thin strata of Clay and highly ferruginous matter reposing in layers, inclined apparently from original deposition, on a mass of coarse greenstone; the lower

Footnote:

The following comment was made on the back of page 1—*On a yellow substance in Cavities in Trap. Daubrisson* vol. 2, p. G 569.

Comments:

D. Such a straight line abutment of dolerite against Triassic sandstone may be seen along the shoreline near the Naval Depot (co-ordinates 519.3 E. 721.8 N to 519.4 E. 721.4 N) and was revealed by the excavations for the Olympic Pool (co-ordinates 519 E. 721.25 N).

E. Dykes of dolerite are common in the Triassic sandstone of the City area (see Lewis 1946, pp. 116, 120; Banks *et al.* 1965).

F. This probably refers to Tertiary sands and clays resting on dolerite at Battery Point near Quayle Street (519 E. 719.2 N) and steeply tilted near Sayer Crescent (518.9 E. 718.6 N). Dolerite boulder beds were exposed in excavation for blocks of flats at the back of Maryville Esplanade near Sayer Crescent (co-ordinates 518.9 E. 718.55 N) (fig. 1 B). The steeply tilted beds are no longer exposed but were referred to by Johnston (1888, p. 282) and illustrated by him (1888, plate opposite p. 280).

G. Presumably a reference to a book by D'Aubisson de Voisins. 'Traité de Géonosie' published in Strasbourg and Paris in 1819. D'Aubisson was one of Werner's pupils who became a Plutonist (Zittel 1901, p. 61).

1836 Febru. Hobart town 839 (3
parts passed into a Conglomerate, from containing so many pebbles of the underlying Greenstone and a white flinty rock, bearing peculiar Organic impressions and Sandstone, all which belong to the older formation and will be subsequently mentioned.—Again further onwards, a H
coarse Sandstone containing some indurated clay is covered by some thicknesses of strata of a white soft aluminosandstone, somewhat like the substance of Huepilacuy at Chiloe. These are capped by a stratum of basalt, a few feet thick, compact with scarcely even a minute vesicle and abounding with very
467 small crystals of red Olivine 3(?) This is separated from a superior and exactly similar stratum of Basalt by one, which has an irregular outline, contains masses of hard basalt, but is itself partly decomposed and resembles Wacke.—By tracing its graduations I found this new comparatively compact substance once to
3469 have been Scoria which without doubt divided two distinct streams

Comments:

H. This can refer only to the Tertiary sands and clays overlain by basalt forming parts of a volcanic centre at and just south of the southern end of Long Beach and extending to the point south of Blinking Billy Point (i.e. from 521.25 E. 716.7 N. to 521.4 E. 716.4 N) (fig. 1 D); this section was subsequently described and figured by Johnston (1888, pp. 279-81) and intensively studied by Spry (1955).

1836 Hobart town 840 (4
of subaqueous Lava. The whole of this mass has been tilted at an angle of 30° to the South.—Following the Basaltic beach for a few hundred yards, there is a cliff, composed of a very compact mass of highly vesicular stone mingled with some compact kinds.—parts have been broken and apparently reunited by heat, others clearly by the agency of water, as shown by containing two or three rounded
3468 pebbles. The cells of the Vesicular Lava, are generally linear, the lines being not infrequently parts of curves and the internal surfaces are lined with sulphur (?).—I can feel no doubt that this little projecting cliff although at present showing(1) no trace of a Crater, was the point, from which the Basalt flowed. In close proximity we have the older greenstone bearing almost the appearance of a
3445 syenite and through this rock the former Volcano must have burst its way.—This is the only spot where I examined any Basalt but in all the South part of both sides of the

Footnote:

(i) *'yellow substance or stains'* in margin at this point.

soft chalk; it is at a little remarkable that such a substance should be included between state & hard Crystalline Limestone. —
On the shore, a few miles South of Hobart town I found the following varieties blending into each other & alternating. 1st a white Cherty
3457 rock with grains of quartz; a blue, slightly
3458 calcareous, siliceous compact Clay-Slate & a
3459 greenish brown rather soft, coarser Clay-Slate.
3460... The white abounds with impressions; in it
...3465 are scattered a very few rounded pebbles of pure Quartz, Quartz rock & of a siliceous Clay Slate. — The occurrence of a very few pebbles in the strata of this formation, is generally common. — Such happens in the Limestone & following cases. — On the flank of Mt. Wellington I noticed amongst similar kinds, 1st a pale blue coarse speckled clay slate
3473 (which perhaps would be called Greywacke) 2d White compact uneven fracture Aluminous
3474 stone & another similar one mottled blue &
3475 yellow. On the opposite shore to Hobart-

Plate 1.—reproduction of p. 8 of Darwin's memorandum on the geology of Hobart Town.

1836 Hobart town 841 (5
estuary, the rock is found in platforms, which present to the sea cliffs, composed of magnificent columns.—In one spot I J
saw white horizontal strata, joining by a great vertical fault to such a mass and at no great distance apparently capped by a K
larger pile of the same substance. This was near Port Arthur, where a considerable mine of Coal (not of very good quality) is worked in Sandstone. I suppose of course these Carboniferous strata are of the same age, with those at Hobart Town and if so the great Basaltic Platforms and the 2 little streams of lava which I have described, belong likewise to one class of events. This whole formation occurs as a fringe, at the base of older series, around the estuary; it likewise extends inland and partly comprises the lower grounds of the fertile valley of the Derwent. I do not think its elevation exceeds a few hundred ft.—We now come to the older

J. Darwin, like Flinders (1801) and many other early navigators and naturalists, regarded the great cliffs of columnar dolerite around the Derwent Estuary as volcanic in origin. By many the cliffs were stated as composed of 'basaltes', probably because of the superficial similarity of the columns to basaltic columns as in Auvergne. It is a little surprising that Darwin who must have climbed over the columns of the Organ Pipes to the top of Mt Wellington did not realise that the columns and the greenstone on top of the mountain were one and the same.

K. This is probably close to Cape Raoul which the 'Beagle' would have had to pass in coming up Storm Bay.

1836 Hobart town 842 (6
formation of rocks, from the degradation of which the first series, have been formed. The upper strata, to the thickness of several hundred feet consist of Sandstone; this rock is subject to some L
variation, but generally is of a yellowish
3466 or red colour, hard, siliceous, and contains rounded grains of Quartz; I have seen some white and some quite red and not siliceous, but these are rather exceptions than common occurrences.—Close to Hobart town, there is such confusion in the strata, that I am very doubtful, whether some of the Quarrys, especially those at some height, are not worked in this rock.—Beneath this older Sandstone we have a very singular assemblage of rocks; they may be described as graduating in character between compact hard blue Clay-Slates, white Cherty or Flinty rocks, white aluminous fine Sandstones (or Claystones) and Limestones; each kind is occasionally met distinct and tolerably perfect; but the greater part is of an intermediate nature.

L. The section described here and to the end of p. 6 of the manuscript is probably based on the section seen (and not recognised as faulted) during the ascent of Mount Wellington from the south, presumably from the coach road or track to Huonville. On Frankland's map (1839) this road is shown leaving the town near what is now Fitzroy Gardens (517.75 E. 719 N) where it crossed Sandy Bay Rivulet, and passing south of this rivulet to about the junction of Huon Road and Ridgeway Road (513.25 E. 716.25 N) beyond which it skirted the headwaters of Dunns Creek and Browns River (fig. 1 A). Limestone is exposed on the north bank of the rivulet near Turnip Field Road (514 E. 716.8 N) where old, small quarries may still be seen. On the bench north of the rivulet there and above the limestone are scattered blocks of Grange Mudstone which might well be described as *'white Cherty or Flinty rocks'*. Further along the old track, near Fern Tree, *'compact hard blue Clay-Slates'* may be recognised as the Fern Tree Mudstone and above this around the Springs is the Triassic sandstone described as *'The Upper strata'*.

1836 Hobart town 843 (7
Perhaps the most abundant varieties might be named whitish flinty Slates.—These rocks abound with impressions of Organic remains—the most abundant are those of the smaller stony Corals and of forms like Retepora; I saw a few of these beautifully silicified: there are likewise the casts of numerous Terebratula, and of one imperfect univalve.—At three or four points, several miles distant from each other, a considerable thickness of the same Limestone strata have been exposed by Quarrys. M

3476-80 Beyond New Town I found a compact crystalline, blackish brown stone, containing some Terebratula, and a few parts almost composed of a small Oyster; there were the impressions of a Pecten; the N
curious figures, representing Corallines, are chiefly found in the flinty beds.—The Limestone in parts becomes slaty and impure; it is very remarkable by con-
3481 taining an irregular stratum of unequal thickness of Snow white, soft (so as to be excavated with spade and pick) pure Calcareous substance; it is a

M. The Berriedale Limestone, quarried at Barossa Road, Tolosa Street, Collinsvale, Granton and elsewhere (see also comment on N).

N. This locality *'Beyond New Town,'* combined with the occurrence of travertine *('Snow white, soft . . . pure Calcareous substance')* between *'strata of hard crystalline Limestone'* makes it likely that the area was that at Barossa Road (513.3 E. 724.4 N) where even as late as the 1940s the quarries had just that appearance. The *'flinty beds'* occur abundantly in this neighbourhood as Grange Mudstone. A less likely locality is in one of the quarries south of the upper part of Tolosa Street (512.2 E. 724.25 N) (fig. 1 C). The only

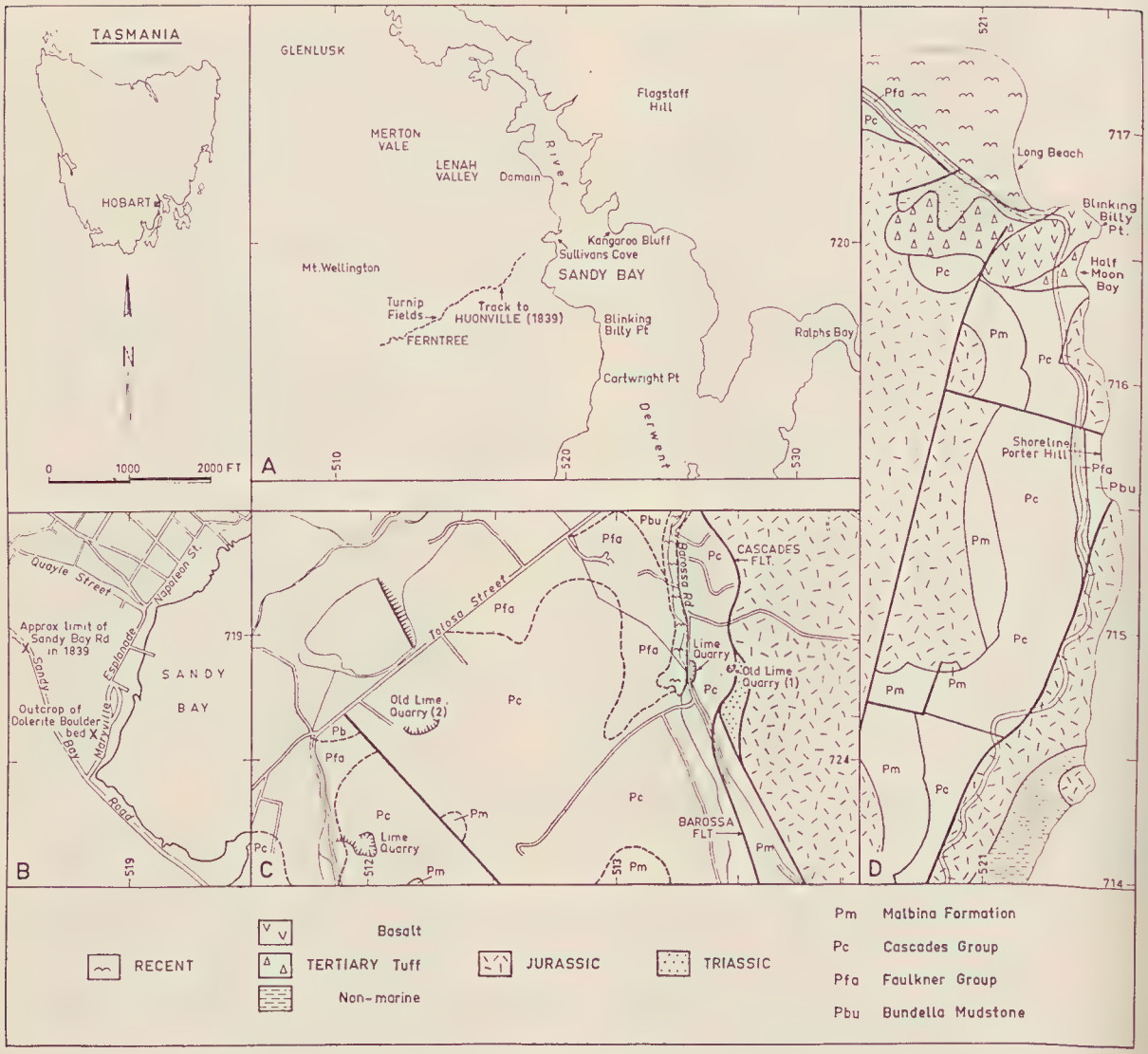

Fig. 1.—Maps illustrating some of the areas visited by Charles Darwin, February 6-16, 1836. Numbers in margins of maps refer to co-ordinates in State Grid System.

A. General map of the Hobart area showing some of the areas visited and the course of the track to Huonville.

B. Sandy Bay area showing some of the localities mentioned in the text.

C. Geological sketch map of the Barossa Road—Tolosa Street area; no geology is shown north of Tolosa Street; the quarry visited by Darwin is that marked (1) or one close to it.

D. Geological sketch map of the Lower Sandy Bay—Taroona area showing localities mentioned in the text.

puzzling feature is the presence of *'a few parts almost composed of a small Oyster'* and might refer to a small outcrop of *Eurydesma*—rich limestone on the Glenlusk Road (508.25 E. 728.1 N) which was certainly worked as a source of lime in the early days of the colony as shown by the presence, size and style of the remains of a small kiln nearby. However, this last possibility is not considered very likely as (a) Darwin would probably have referred to this locality as beyond Humphrey's Rivulet which was already named (Frankland's map 1839), (b) *'flinty beds'* are not at all close (see Sutherland 1964 maps), (c) there is no present evidence of travertine there, (d) the *Eurydesma* would hardly be referred to as small, (e) in his published description Darwin referred to this being *'near New Town'* (1884, p. 155), and (f) on a chart (Dept of Lands, Buckingham Plan 17 A,

dated Nov. 1832) a lime kiln is shown at the Barossa Road locality but nowhere else north of New Town to the limits of the map near Granton.

1836 Hobart town 844 (8
soft chalk; it is not a little remarkable that such a substance should be included between strata of hard crystalline Limestone.—

On the shore, a few miles South of Hobart town I found the following O
3457-58 varieties blending into each other and alternating. (i) a white Cherty rock with
3459 grains of quartz; a blue slightly cal-
3460-65 careous, siliceous compact Clay-Slate and a greenish brown rather softer, coarser Clay-Slate. The whole abounds with impressions; in it are scattered a very few rounded pebbles of pure Quartz, Quartz rock and some of a Micaceous Clay-Slate.—

The occurrence of a very few pebbles in the strata of this formation is generally common.—Such happens in the Limestone and following cases.—On the flank of Mount Wellington I noticed amongst similar kinds, first a pale blue coarse
3473 speckled clay Slate which perhaps would be called Greywacke), a white compact-
3474 uneven fracture aluminous stone and
3475 another similar one mottled blue and yellow. On the opposite shore to Hobart P

O. There are two possibilities for this locality (i) Porter Hill (521.45 E. 715.7 N) or (ii) south of Blackmans Bay (518 E.703 N).

At Porter Hill siltstones and thin impure limestones (perhaps *'greenish brown rather softer, coarser Clay-Slate' and 'blue slightly calcareous, siliceous compact Clay-Slate' . . . 'with impressions')* are overlain by relatively unfossiliferous sandstones and siltstones and then by Grange Mudstone (perhaps *'white Cherty rock with grains of Quartz'* which occurs as float near the top of the cliffs just behind the shoreline (fig. 1 D).

South of Blackmans Bay the Grange Mudstone outcrops in shore platforms and cliffs and includes *'white cherty rocks'* as well as *'blue . . . Clay-Slate.'* However the greenish brown rocks in the Grange Mudstone there are very hard and very fine-grained not *'softer'* or *'coarser'* as stated by Darwin. In addition, the dolerite sills and dykes are so beautifully shown in the cliff sections in this area that an astute observer such as Darwin could hardly have failed to see and comment on them had he visited the locality.

Thus on balance the Porter Hill locality is considered the more likely.

P. From near the Ferry Wharf (522.E 721.55 N) at Bellerive to the western end of Bellerive Beach (522.5 E. 720.9 N) are shore platforms and low cliffs of Ferntree Mudstone with the characters of the rocks described from the *'opposite shore to Hobart town.'* Spiriferids (all brachiopods seem to have been referred to by Darwin as *'Terebratula')* and pebbles are present but rare. The joints project upwards as noted by Darwin (footnote on p. 9).

1836 Hobart town 845 (9
town, there are white strata and an ex-
3447 cessively fine grained aluminous Sandstone (?) with an uneven fracture, which in parts becomes more sandy in other passes
3448 into a Porcelain rock with conchoidal fracture; the whole series graduates into an underlying blue stone partaking of the characters of Clay Slate.—In both are found rarely casts of Terebratula and pebbles.—(a) Near New Norfolk a similar white stone, passes into a very hard Q
brittle s . ous one with straight frac-
3482 ture—whose grains of quartz are blended and almost dissolved in a siliceous paste.

Here pebbles of pure quartz were more frequent than elsewhere. Mr Frankland,
3496-99 the Surveyor-General, gave me specimens of the white Aluminous stone, abounding with impressions of Shells from the Huon R
River and likewise, a blackish Limestone almost composed of parts of Bivalves
3500 from the island of Maria.—(B) We thus see this formation extends over the whole SE extremity of Van Diemen's land.—With respect to its connection with the first formation

Footnote:

(a) and *(B)* appear in the margin at the places indicated and refer to the following notes which appear on the back of page 9.

(a) also all the strata are crossed by fissures the sides of which are penetrated with ferruginous matter, so as, from being harder, to project upwards.—

(B) I have also Terebratula from the neck of the Peninsula (where the gards is kept) of the penal Settlement (3630:31:32). T

Q. There are too many outcrops meeting this description near New Norfolk to allow specification of a locality. However it is likely that the coach on which Darwin travelled to and from New Norfolk (Barlow 1933, p. 389) stopped at the Black Snake Inn near the present western end of the Bridgewater Causeway.

At this locality Ferntree Mudstone occurs which meets the description.

R. There is insufficient detail given to allow recognition of a locality or formation.

S. This reference is certainly to the Darlington Limestone from the cliffs and shore platforms north of Darlington, Maria Island. This limestone has long been known for its richness in *Eurydesma* (see also comment HH).

T. *'The neck of the Peninsula'* is Eaglehawk Neck and *'Terebratula'* again refers to spiriferids which are fairly common in the cliffs and shore platforms from Clydes Island (incorrectly called Nuroo Island by Banks and Williams 1965) to the Blowhole. These specimens almost certainly formed the basis of Sowerby's description of *Spirifera avicula* in Darwin's *'Geological Observations . . .'* and probably also of *Spirifera vespertilio* in the same publication.

1836 Hobart town 846 (10 I was not fortunate enough to find an actual junction; but as in this latter, pebbles from the second and older series are found, the two formations must be quite distinct. In a like manner neither did I see the inferior junction; the white flinty Slates, being the lowest stratified rocks which are visible. The pebbles however of Quartz rock and Micaceous Slate, show that a third and older formation must be not very far distant.—

Yet in this immediate neighbourhood I believe the lower strata of the second series generally rest on a coarse greenstone which x(i) *has burst through them when in a fluid state. I think this, from the entire absence of pebbles of Green- distant from this rock; and from its close juxtaposition on either hand of masses of the stratified stones, which would appear to be the effect of violence.—I confess however, I saw no cases, where the Stratifications pointed out this relation, in a satisfactory manner. The strata are seldom horizontal but are gently inclined and as far as I can ascertain in* U

(i) this is the manner in which Darwin presumably indicated the insertion at the point shown of the phrase *'when in a fluid state.'*

U. This correct ordering of the dolerite with respect to the Permian rocks represents the earliest correct attempt to do this. It was unfortunately not published.

1936 Hobart town 847 (11 no particular direction. Almost all the hills, even those of quite secondary height, consist of Greenstones. Fringed with these strata.—On the opposite side of the water
3451 *to Hobart town a hill composed of* V
3453 *ordinary, granular, and fine grained*
3454 *ferruginous Greenstones was skirted in the upper parts of its sides by gently inclined strata, which appeared (but I do not feel at all sure) to have undergone some*
3449 *alteration; there were bluish siliceous - Aluminous stones with minute grains of Quartz and white ones of a similar nature,*
3450 *which are indurated and fractured.— Mount Wellington, the most conspicuous feature in this neighbourhood rising close behind the town to the height of*(i) *3,100 ft is similarly constituted.—Passing over the low ground at its foot composed of* W *the first series, we first reach in the ascent the anomalous flinty and slaty rocks, then come to the Sandstones; these strata extend to a height perhaps of 1200 ft, above which there is nothing but Greenstone.—As the Strata on the sides are not very much disturbed,*

(i) *'Anguln. M. Beagle'* is written in the margin at this point.

V. This locality is a little difficult to identify with certainty but is probably Flagstaff Hill (523.7 E. 726.1 N) on which Ferntree Mudstone *('bluish siliceous-Aluminous stones . . .')* outcrops almost to the top on the eastern side. The top is occupied by dolerite *('Greenstone')*, part of a wide dyke forming most of the western face of the hill.

W. See comment L. Darwin did not see the faults which greatly disturb the section between Hobart and the summit of Mt Wellington (see Banks *et al.* 1965).

1836 Hobart town 849 (12 perhaps this height nearly expresses the thickness of this formation.—All the Greenstone which crowns this mountain is of a very uniform character; it is rather
3472 *coarse and contains*(i) *crystals of Hornblende; it strongly affects the Magnetic needle; one side of the summit shows*(ii) *a large columnar structure; generally there s a grand accumulation of immense loose fragments.—I have as yet only mentioned the Trappean rocks incidentally, some as belonging to the first and more modern, others to the second series of strata. From my limited observations I have not been able to ascertain any difference in these*
3451 *Trappean rocks of two ages.—Indiscrim-*
3453 *inately over the country, we find ordinary*
3454 *Greenstone graduating into a granular*
3456 *kind which assumes a Syenitic appearance. These probably belong to the older set, and are generally found in the higher* X *hills ; there are however numberless exceptions; on the coast some miles South of the town, there is a continued mass* Y
3455 *of a Greenstone composed of a*

(i) *'& yellow cryst.'* is written in the margin at this point.

(ii) *'heavy'* is written in the margin at this point.

X. It is interesting to see that Darwin recognised that most of the higher hills were capped by dolerite. His *'granular kind which assumes a Syenitic appearance'* refers to the coarser grained varieties (and perhaps pegmatitic or granophyric differentiates) which are widespread. Professor Carey points out (pers. comm.) that in places (on sea shores) weathering causes the dolerite to become paler and this may be the origin of the *'syenitic appearance.'* I have examined the pale weathered dolerite and the colour is due to the fact that within the zone of wave washing or splash the feldspar weathers to clay, thus changing from transparent or translucent to white and chalky looking, before the ferromagnesian minerals oxidise and hydrolyse to red iron hydroxides. Where the feldspar is translucent, the rock is dark but where the feldspar is chalky, the rock is mottled and looks syenitic.

Y. This is most likely to refer to the dolerite between Porter Hill and Cartwright Point (521.4 E. 714.4 N) where schlieren and masses of pegmatitic feldspar-rich dolerite occur. Somewhat similar rocks occur at Crayfish Point (520.9 E. 712.2 N) and at the western end of Taroona Beach (520.3 E. 711.9 N) but it is unlikely that Darwin travelled down the coast as far as Crayfish

Point or he would have seen and commented on the unusual boulder beds between Cartwright and Crayfish Points.

1836 Hobart Town 849 (13 numerous Crystals of Feldspar and Hornblende (and Mica ?) mingled in patches with a compact Feldspar. This rock in mass, had the aspect of a Granite. These Trappean formations (including in that name ancient Lava streams) prevail most extensively over the whole Island.—I hear everywhere of cascades of Columns and detached conical hills—The summit of Mount Wellington is broad, level and of considerable extent; looking to the W. and N.W. numberless mountains of the same form and height are seen; these in parts are said almost Z *to unite into an elevated central plateau. I may here mention some facts obligingly communicated to me by Mr Frankland, which will give a general outline of the Geology of the Island.—The central mountains which occupy a large space; and of which Mount Wellington may be considered as the termination in one direction entirely consists of Greenstone.—On their Northern*

Z. This comment is an interesting, unpublished forerunner of Davies' recognition of the 'Higher Plateau Surface' (Davies 1959), hinted at also in Darwin's diary (Barlow 1933, p. 389).

1836 Hobart town 850 (14 boundary (20 to 30 miles SW of Launceston) there is an extensive formation of Limestone, Conglomerate, and Clay. Slate.—From Quamby Bluff I have specimens of this latter rock marked with
2470) *impressions of the Corallines and Tere-*
2471) *bratulate, so frequently mentioned.—Hence there can be little doubt concerning the age of the clay. Slate; and when we consider the variable nature of the Flinty Slate and Limestone beds, containing pebbles near Hobart town; it is highly probable that the whole formation of the North belongs to the same one of which the SE extremity is composed. We shall thus see one continuous series sweeping around the central nucleus of Greenstone.—On the NE coast Granite is extensively found; and on the opposite ex-*
tremity, the SW, there is a great form- AA
ation of white Quartz; so conspicuous is this from its brilliant appearance, that Navigators noticing it from a distance, have thought it to be Snow.—The level district at the sources of the Derwent and Tamar BB

AA. The *'great formation of white Quartz'* must refer to the ranges of Precambrian quartzites and quartz schists which characterise south-western Tasmania. This passage is an almost direct transcription from Flinders' (1801) description in his report on the first circumnavigation of V.D.L.

BB. The conjunction of *'level district', 'silicified wood', 'beds of agate pebbles'* and *'salt'* indicate that this area is that between Antill Ponds and about Conara, perhaps especially between Tunbridge and Ross.

1836 Hobart town 851 (15
3483- *are remarkable by the large quantities of*
3488 *silicified wood found there; in the same district are found beds of Agate pebbles. Salt likewise is procured from some ponds which periodically in the dry season leave an incrustation of this substance.—Perhaps these latter circumstances indicate another and distinct formation.—Within the outskirts of Hobart town, there is a Quarry in Limestone, which I have delayed mentioning because I am entirely ignorant in which class it ought to be arranged. The limestone is of a pale yellow colour, not very compact, of a minute Crystalline structure; its strata are inclined at an angle of 45°. It is everywhere traversed by a very small linear* CC *cavities, which resemble those found in some Freshwater Limestones, to which*
3495 *stones this bears much resemblance.—Contains occasional layers and nodules of ordinary flint and still more occasionally a few small pebbles.—Those which I saw were about twice as large as beans, and consisted of pure Quartz and Quartz rock.—Some of*

CC This fuller description of the *'Travertin with extinct plants'* referred to by Darwin in *'Geological Observations'* . . shows that this could not be the Geilston Travertine as thought by Johnston (1888, p. 286) on the basis of the shorter published description. The locality, topography, lithology and structure are all wrong if the Geilston Travertine is being considered but the locality and topography and to some extent the lithology suggest that it was the quarry in upper Burnett Street which supplied lime to Shoobridge's limekiln (Johnston 1888, pp. 248, 286). This quarry appears in a painting of Hobart Town by Surveyor-General G. W. Evans dated 1828 and published as a print by R. Ackerman of London (copy of print in collection of Dr C. Craig, Launceston, 'The Aquatint of Hobart Town 1828', Craig 1964, p. 34). The painting shows the quarry in about the position of the western end of Burnett Street with a building nearby to the north-west. The quarry site is shown on a chart in the archives of the Department of Lands (Plan of Lime Kiln Reserve, James Combes, 1863) and was in the area bounded by Arthur, Browne, Lochner and Hamilton Streets and is now partly occupied by a reserve. The kiln is shown in the trapezoidal block bounded by Mary, Burnett, Arthur and Murray Streets.

1836 Hobart town 852 (16
3489- *the lower strata, abound with distinct im-*
pressions of various leaves, which are said
3494 *to differ from those now existing.—Very many Shells have been found.—The Limestone is covered by a mass of Alluvium, several feet thick, of rather a singular nature. Fragments of some Trappean rock, by their decomposition, now appear*

as balls imbedded in a Wacke; the interstices however and in parts, masses, consist of a quite white soft Calcareo-Aluminous powder. — This resembles a substance which was found under very similar circumstances at St Jago in Chili. This singular mixture of rubbish has also filled up a vertical fissure after the manner of a dyke in the Limestone, DD *and until I found in it a rounded pebble, I was uncertain of its nature.—I suppose, the Limestone, after the displacement of its strata, but yet whilst beneath the Water, bearing lime in solution, was covered, by some subterranean violence with the fragments of Volcanic rocks.— This kind of Limestone has only been found on the side of a small hill; as from the purity*

DD. Probably the first record of a Neptunian dyke from Australia.

1836 Hobart town 853 (17 of the Lime, which is produced[1] *from it it is an object of value, it has been searched for with some care.— It is probable that this very limited formation was deposited either in a lake or small creek; the nature of the pebbles would lead me to class it with the older formation; but on the other hand its unconsolidated nature and the impressions of leaves connect it with the more modern series. I now come to a subject which I have so frequently discussed in my Geological Memoranda; viz recent movements in the level of the land. On both sides of the Bay and along nearly the whole line of coast broken shells are found on the land to the height of 30 to 40 ft in quantities which render it rather difficult to believe they have all been carried there by the Aborigines. Amongst these shells are found many rounded pebbles and individuals too small to be brought for purpose of eating; the coast moreover in a few places, by its outline, obscurely shows a small*

(i) '*Examine for bones*' is written obliquely across the top of the line here

1836 Hobart town 854 (18 vertical retreat; on the other hand, much of the shells appear collected in heaps, in which instruments of the Natives have been found and hence clearly bespeak their origin.—In Ralph Bay, Mr Frankland, who accompanied me in these excursions, and myself, found a beach from 12 to 15 ft above present high water mark, and covered with vegetation, many of the pebbles in which, were coated with Serpulae. This instance is of no value, because the creek is only separated from a larger expanse of water by a low strip of land, which the tides might have heaped up, and before this had happened, a higher surf might have thrown up the
(a) beach.—Again on the banks of the Derwent River where the water is fresh or so brackish that marine shells will not live even for some miles lower down, the same layers of shells, intermingled with
(b) masses of shingle are found on the banks, elevated from 6 to 10 ft above the present highest tides. When the bay was less filled with the EE

Footnote:

The following notes appear on the reverse of p. 18.

(a) N.B.: That changes are still in progress in this little cove is certain from the fact that oysters which two years previously were abundant, have entirely ceased to exist.

(b) I may mention also that some of the little side valleys have that peculiar flat-bottomed structure which indicate that they formerly were occupied by the water as small coves

EE. There appears to be a page missing here.

Hobart town 855 (20 Australian caves.—Mr Frankland has determined to investigate this subject and likewise the recent rise of the land; there can be little doubt he will make some interesting discoveries. Before concluding I will give a summary of the history of the formations; but, when it is considered that this Island nearly equals Ireland in extent it will be manifest what a shadowy outline such must be. At a very early period the great Quartz formation in the SW extremity probably existed as one or or more island; as likewise perhaps did the Granite of the NE[a]*.—In the surrounding or intervening ocean, thick mass of strata were accumulated, which compose the second series; Hence we have the pebbles of pure quartz and Quartz rock.—*

In this sea Corallines abounded, and amongst them numerous Terebratula and beds of oysters.—During this epoch, the subterranean forces propelled upwards large masses of Greenstones; this propulsion appears to have taken place

Footnote:

The following appears on the reverse of p. 20.

(a) for some other rocks v. Lesson's Zoologie FF

FF. R. P. Lesson was naturalist on the French survey ship *La Coquille* which visited Australia in the period 1822-1825. The ship did not visit Hobart but while in Sydney (Jan. 17-Mar. 22, 1824) the naturalist 'procured about 30 specimens of rocks from Van Diemen's Land: pegmatites, rocks of a tertiary terrain, spirifers, serpentines, asbestos, an intermediate' (?transition) 'limestone' (Duperrey 1830, *Zool.* II, p. 144).

1836 Hobart town 856 (21 in mass, and as the superincumbent strata are not much displaced, without much partial violence.—In this state we either

have an Archipelago crowded with Islands or a land deeply indented by arms of the Sea; in such spaces our first or most modern formation was deposited from the wear and tear of the older[a].—*During this period igneous rocks were both poured out as Lava streams and injected masses violently ruptured the strata. We believe lastly the land attained its present position after some considerable oscillations of level.—*

In attempting to compare the Geology of this country with that of the Colony of New South Wales, a considerable resemblance may be observed in the Carboniferous series, which in both places forms the upper formation. At the distance of 600 (Geograph:) miles it appears very doubtful how much confidence may be given to such resemblances in ascertaining their coeval origin. I think

Footnote:

On the reverse of p. 21.

(a) I should observe in such newer patches of strata, many probably belong to rather distant periods of time but its first rough classification they come into the formation.—

and also

'Macc. Class of Rocks p. 471 on Hypersthene appearing at passage (?) from greenstone to syenite. GG GG. Probably a reference to a publication by John Macculloch, the Scottish mineralogist and geologist, *'A Geological Classification of Rocks, with Descriptive Synopses, comprising the Elements of Practical Geology.* London 1821.

1836 Hobart town 857 (22 however it is not improbable, that on an extended examination, a considerable degree of parallelism in the formations of the two countries would be discovered. The Limestones of Argyle with Organic remains, might correspond with the second series of this place, and the Quartziferous Granites of Australia, with the Quartz rock of Van Diemen's land.—On first examining the country, from the preponderance of Trappean and ancient Volcanic rock I was struck with the resemblance of it to New Zealand. There also I believed there were two distinct formations; the older containing Limestones and Cherty beds, and the more modern Lignites and Sandstones.—

With respect to the absolute age of the second series of this place, I fear the fossils are far too scanty even to offer a conjecture. The subject remains a field open to the examination of the rising Geologists of Tasmania.—

Footnote:

On the reverse of p. 22.

May 25, 1836, Memoir of Van Diemen's Land. of Mr Frankland HH

HH. This refers to a paper by Frankland on Maria Island *(Proc. Geol. Soc.* 1836, ii, p. 415), read on May 25, 1836.

The microfilm on which this transcription is based was supplied by The Librarian, Cambridge University and was marked Darwin Ms, 38 (1) ff 837-857; original pages of ms. about 8.1" × 10". Pages are numbered 1 to 22 (19 is missing) in Darwin's script; numbers 837-857 are not in Darwin's script.

A Catalogue of Darwin's Specimens from Tasmania compiled from his manuscript.

For this purpose it is assumed that the numbers in the margins of the manuscript refer to specimen numbers collected at the sites mentioned or of the rocks etc. mentioned in the immediately subjacent text. The numbers are in Darwin's script. Quotes from Darwin's text are in italics.

3445 *greenstone* (dolerite); *coast south of Hobart town* (Half Moon Bay, Lower Sandy Bay 521.4 E. 716.3 N) (see Spry 1955)

3447 fine grained aluminous sandstone (Ferntree Mudstone); *opposite shore to Hobart town* (Bellerive-Kangaroo Bluff foreshore)

3448 *Porcelain rock with conchoidal fracture* (Ferntree Mudstone); locality as 3447

3449 *bluish siliceous-Aluminous stones* (probably Ferntree Mudstone); *opposite side of the water to Hobart town* (near Bellerive, possibly Flagstaff Hill, Gordons Hill or Grasstree Hill)

3450 *white ones* (stones) *of a similar nature* (to 3449) (probably Ferntree Mudstone); locality as 3449

3451, 53, 54 *ferruginous greenstone* (p. 11 of manuscript) (dolerite or weathered dolerite); locality as 3449

3455 *greenstone* (dolerite, perhaps pegmatitic or granophyric); *on the coast some miles south of the town* (possibly Porter Hill (521.52 E. 715.55 N) to Cartwright Point or Crayfish Point, Taroona)

3456 *greenstone* (dolerite); locality uncertain

3457 *white cherty rock . . . with impressions* (? Grange Mudstone or top of Bundella Mudstone); *shore a few miles south of Hobart* (Porter Hill or cliffs south of Blackmans Bay)

3458 *blue slightly calcareous siliceous compact Clay-Slate . . . with impressions* (Bundella Mudstone); locality as 3457 (must be Porter Hill)

3459 *greenish brown rather softer, coarser Clay-Slate . . . with impressions* (Bundella Mudstone); locality as 3457, 8

3460-65 *impressions* from area of 3457-59 (fossils as moulds); locality as 3458

3466 *sandstone* (Springs Sandstone); (Locality not certain, could be Mt Wellingon; see p. 6 of ms.)

3467 *basalt with red olivine (?)* (basalt with olivine altered to iddingsite); *coast south of the town* (Long Beach, Sandy Bay; see Spry 1955)

3468 *vesicular lava;* locality as 3467

3469 *scoria;* locality as 3467

2470-71 *Clay Slate with impressions of . . . Corallines and Terebratulae* (Permian fossiliferous mudstone, probably Golden Valley Group); *Quamby Bluff* (several richly fossiliferous localities occur in this area); (*'2470'* and *'2471'* may be a slip of the pen and may have been intended to be 3470 and 3471 as all of Darwin's other numbers for Tasmanian material commence with '3'; and there are no numbers 3470 and 3471 in the margins)

3472 *greenstone* (dolerite); *top of Mt Wellington*

3473 *pale blue coarse speckled clay slate* (? Ferntree Mudstone); *flanks of Mt Wellington*

3474 *white compact uneven fracture aluminous stone* (?Ferntree Mudstone or siltstone in Malbina Formation); *flanks of Mt Wellington*

3475 *Mottled blue and yellow aluminous stone* (probably Ferntree Mudstone); *flanks of Mt Wellington*

3476-80 *compact crystalline blackish brown stone containing Terebratulae etc.* (Berriedale Limestone); *beyond New Town* (probably quarry at Barossa Road, 513.3 E. 724.3 N; possibly quarry near Tolosa Street, 512.2 E. 724.3 N)

3481 *snow white, soft . . . pure calcareous substance* (travertine); *beyond New Town* (locality as 3476-80)

3482 *white stone . . . quartz . . . in a siliceous paste* (Ferntree Mudstone); *near New Norfolk;* probably near Black Snake Inn.

3483-88 *silicified wood; the level district at the source of the Derwent and Tamar* (Campbell Town-Tunbridge region)

3489-94 *impressions of leaves* (fossil dicotyledons); *quarry of limestone . . . within Hobart Town* (top of Burnett Street; approx. 517.4 E. 721.4 N) (see Johnston 1888, p. 286)

3495 *nodules of ordinary flint in fresh-water limestone;* locality as 3489-94

3496-99 *white aluminous stone abounding with the impressions of shells; Huon River; donated by G. Frankland, Surveyor-General*

3500 *blackish limestone . . . parts of Bivalves* (Darlington Limestone with *Eurydesma); Maria Island* ('Fossil Cliffs', Maria Island); *donated by G. Frankland,* Surveyor-General

3630, 31, 32 *Terebratula* (brachiopods); *the neck of the Peninsula* (Eaglehawk Neck)

Darwin's rock collection from Tasmania is now housed in the Department of Mineralogy and Petrology, University of Cambridge (T. G. Vallance, *pers. comm.*, July 5, 1970).

DARWIN'S ACTIVITIES IN HOBART

An exasperated and rather homesick young man of almost 27 wrote to his sister, Susan Darwin, from Sydney, on 28th January 1836, *'From Hobart town being superadded to the list of places . . .'* (Barlow 1945, p. 133). It may be deduced that Darwin was not aware that the 'Beagle' had been originally scheduled to visit Tasmania depending on the season (*Narrative, 2,* p. 33; instructions to FitzRoy) and one may suspect that this part of the itinerary became known to him only in Sydney. Thus, during the evening of Friday, 5th February 1836, a blustery wet day (*Narrative,* 2, p. 624), Charles Darwin reached Hobart Town in the 'Beagle' (*Narrative of the Surveying Voyages of H.M.S. Adventure and Beagle,* vol. III, p. 532). Darwin records in his narrative that he walked around the streets of Hobart during the morning of the sixth (*ibid,* vol. III, p. 532) and subsequently made *'several pleasant little excursions.'* From the Narrative and his diary (Barlow 1933, pp. 388-9) it is clear that one of these was to what is now Bellerive which he reached by steam boat. During the interval Feb. 7 to Feb. 10 he not only visited Bellerive but also made two attempts to climb Mt Wellington. The first attempt was foiled by *'. . the thickness of the wood,'* and the second, though successful, was rather strenuous as the guide *'was a stupid fellow, and conducted us to the damp southern side of the mountain.'* From the summit he noticed 'to northward . . . wooded mountains of about the same elevation and tame outline as the one on which we stood.' (Barlow 1933). Between the 12th and the 15th he went riding *('several pleasant rides')* with Mr Frankland, the Surveyor-General, one of these being to Ralph's Bay (*'Geological Observations . .'* p. 141). From *'Geological Observations . . .'* it may be further deduced that he visited limestone quarries *'near New Town,'* revealed by this new memorandum to be most probably the quarries at the northern end of Barossa Road. It is also confidently deducible (*'Geological Observations . . .'* p. 139) that he examined the volcanic centre just south of Long Beach, Sandy Bay. The new memorandum casts further light on his *'pleasant little excursions.'* His *'long walk on the side of the bay opposite the town'* almost certainly included an ascent of Flagstaff Hill. He seems likely to have seen the dolerite dyke now cut by Augusta Road near Waverley Ave (memorandum, p. 1), Note A). His *'excursion'* along the shore of the town took in the Tertiary sediments behind what is now Maryville Esplanade, at that time probably a sandy beach backed by cliffs of Tertiary, and extended to Long Beach, to Porter Hill where he collected Permian fossils, and probably beyond this to Cartwrights Point, near which he saw the dolerite which *'had the aspect of a granite.'* (memo, p. 13). He also visited the lime quarry in Burnett Street (see comment CC). In his diary he noted that on 16th February 'the weather was cloudy and prolonged the stay beyond what was expected.' The cloudiness prevented observations of the sun and calculation of the latitude and longitude therefrom involving the use of the many chronometers carried by the 'Beagle'. As such observations were a critical part of the ship's task in circumnavigating the globe, the ship stayed in port until such observations could be made. On 16th February, Darwin went by stage coach to New Norfolk, probably taking the opportunity to collect a specimen when the coach stopped at the inn at Black Snake Gully. Taking all these statements and deductions about his activities together, about eight of the 11 complete days spent in Hobart Town can be accounted for (Mount Wellington 2 days; Hobart streets ½ day; Bellerive 1 day; Ralphs Bay 1 day; Barossa Road 1 day; New Norfolk 1 day; Sandy Bay at least 1 day; Burnett

Street quarry ½ day). As at least two of the 11 days were sabbaths, and likely to be observed as days of rest and letter writing (see below re letter to Katherine) almost all his time in Hobart can be accounted for. The 'Beagle' sailed from Hobart on 17th February, having been 11 days in port (Darwin in the *Narrative*, p. 534, apparently erroneously gave the figure as 10 days).

Darwin wrote in his journal (pp. 532, 533, 536), . . . *first aspect of the place* (Hobart) . . . *very inferior to that of Sydney . . . latter a city this only a town . . . streets fine and broad . . . shops appeared good . . . Mount Wellington of little picturesque beauty . . . if I emigrate choose this rather than Sydney . . . climate and aspect of country . . . society on a pleasanter footing . . . free from contamination of rich convicts . . . colony appeared well-governed . . . streets at night more orderly than those of an English town.'* It is also clear from a letter Darwin wrote to his sister Katherine 14.2.1836) (Barlow 1945, p. 135) that he preferred Hobart to Sydney—*'all on board like this place better than Sydney.'* The reasons given suggest some home-sickness—*'. . . the Gardens . . . delightfully resemble England . . .'* and a liking for the society—*'the pleasant society there is here.'* Some of that society Darwin met when he dined at the Attorneys-General (Mr Alfred Stephen, later Chief Justice of New South Wales) on the 13th February, the day after his twenty-seventh birthday (Barlow 1945, p. 135). Between the 12th and 15th February Darwin, having been introduced to George Frankland, 'was much in his society' and 'passed at his house the most agreeable evenings since leaving England.' (Barlow 1933, p. 389). His impressions seem to have been, on the whole, favourable.

The visit of the 'Beagle' received scant attention in the local press, the main interest being to try to get the ship to send a party to survey the Actaeon Rocks on which a vessel, not the first to do so, had recently run aground.

DATING THE MEMORANDUM

It is likely that the memorandum was written before the preparation of the journal of researches published in 1839 as no geological ages based on the fossils collected are given in the memo but some ages are given in the journal. It is probable that it was written at sea (i.e. before Oct. 2, 1836) before Darwin was able to refer to any of the more recently published works on fossils. The reference on the back of p. 22 to the memo by Frankland on Maria Island would have had to be added after Darwin reached England.

THE SIGNIFICANCE OF THE MEMORANDUM TO TAXONOMIC PALAEONTOLOGISTS

Although not stated in the memorandum, it is very likely that the numbers in the margins refer to specimens he collected, and this gains further credence from the existence in the British Museum of Natural History of a specimen with '498' on it in Darwin's script and from Tasmania. He tested some material from the volcanic rocks at Sandy Bay with a blowpipe but this could have been done *in situ* or on the ship rather than in England as he had a blowpipe with him (de Beer 1963, p. 34). As shown in the catalogue herewith, compiled from his numbers, he collected Permian fossils from the Porter Hill area and the area near the quarries at the northern end of Barossa Road, and was given Permian fossils from Quamby Bluff, Eaglehawk Neck and the Huon. He collected Tertiary plants at Burnett Street and was given pieces of silicified wood from the Ross-Tunbridge area.

In the memo, Darwin refers infrequently to fossils by name. 'Smaller stony corals' *(Stenopora)*, forms like *Retepora* (fenestellids) and *Terebratula* (this term was used for all brachiopods) abound in 'whitish flinty Slates' (probably Grange Mudstone) (memo. p. 7) but no specimen numbers are given and if the inference made (comment L) that he saw these near the Turnip Fields during ascent of or descent from Mount Wellington is correct, it is perhaps not surprising that he did not collect any, being wise about not carrying extra weight up the mountain and being too exhausted or too late on the way down to worry about collecting specimens. They did not reach the ship till 8 o'clock 'after a severe day's work (*J. Res. 1839, p. 536*). Near Barossa Road quarry he reported (memo. p. 7) *Terebratula*, a small oyster, *Pecten* and corallines and apparently collected five specimens. He also apparently collected six specimens of 'impressions' from the Porter Hill area (memo p. 8). He noted *'Terebratula'* from Bellerive but did not collect any and included donated specimens of *'Terebratula'* from Quamby Bluff and Eaglehawk Neck and corallines *(Stenopora)* from Quamby Bluff in his collections.

Subsequent work by Sowerby reported in *'Geological Observations'* (pp. 158-160) led to replacement of the term 'Terebratula' by the terms 'Producta' and 'Spirifera' and Lonsdale (*ibid*, pp. 161, 169) named the 'corallines' *Stenopora*, and the 'Retepora' *Fenestella*. Three specimens of *Producta brachythaerus* are quoted by Sowerby; one, the only one of which he was certain, in grey limestone (presumably Berriedale Limestone from Barossa Road where *T. brachythaera* (Morris) is common); another, an internal mould of the brachial valve, in a 'light rusty-brown' stone; and a third, an internal mould of the pedicle valve, in a 'nearly similar stone.' Of these only the second is extant and recognisable in the B.M.N.H. (B.M. 19298) and is *Strophalosia* (Hill 1950, p. 19). Hill (1950, p. 19) noted that it bears the printed number '498' in the type of script used by Darwin. In this case, assuming that the label has not been displaced, the specimen is one of those given to Darwin by Frankland from the Huon. I have seen the specimen in the British Museum and it is an internal mould with a ferruginous coating and the block also contains a *Neospirifer sp.*, *Stenopora*, ostracodes and productid spines. My diagnosis of its locale at the time (1956) was that it most probably came from the Rayner Sandstone which outcrops above the Channel Highway at Porter Hill, but similar rocks occur in the Huon area, e.g. near Cygnet. The brachial valve most resembles that of *S. jukesi* which occurs in the Cascades Group near Hobart, and its correlates elsewhere. By the courtesy of the B.M.N.H. I have been able to obtain pieces of the matrix and rubber casts of the *Strophalosia* and associated fossils. These show that the matrix consists of finely mottled pink and white siltstone with angular sand-grade clasts of quartz and larger clasts of (?) chlorite schist and moulds

of fossils, mainly polyzoa, coated with limonitic encrustation. Comparison with specimens of Rayner Sandstone from Porter Hill suggest that the provenance was elsewhere. The rubber casts show the presence of a ramose *Stenopora* and *Peruvispira allandalensis* Fletcher.

The specimen on which the diagnosis of *Spirifera subradiata* Sowerby is based was apparently the original shell of a brachial valve. This is most likely to have come from the Barossa Road area, based on the range of this species in Tasmania and mode of preservation, but an origin from Eaglehawk Neck is not impossible. The provenance of the specimens of *Spirifera trapezoidalis* Sowerby is not clear although the description of the matrix a 'dark, rusty, grey limestone' suggests some of the limestone within the Bundella Mudstone on the shoreline at Porter Hill. No light is cast on the provenance of *Spirifera paucicostata* Sowerby but the internal moulds on which *Spirifera vespertilio* and *S. avicula* were based almost certainly came from Eaglehawk Neck where such moulds are common in the Malbina Formation. A specimen, B10858, in the B.M.N.H. is recorded as 'said to be *Spirifer vespertilio*. . . . Charles Darwin collection.' The specimen, a medium-grey siltstone, contains external moulds of both the normal (Strzelecki 1845, pl. XVII, f. 1) and short variety (*ibid,* pl. XVII, f. 3), the former referred to as *Sulciplica transversa* by Waterhouse (1968, p. 27), the latter as *?Licharewia phalaena* (*ibid,* p. 24) associated with *Ingelarella angulata* Campbell and crinoid columnals in a matrix characteristic of the Malbina Formation. The lithology and associated fossils taken in conjunction with Darwin's memo strongly suggest an origin from Eaglehawk Neck. No extant internal moulds assignable to Darwin's collection are known.

The origin of the polyzoa described by Lonsdale from Darwin's collection can also be ascertained with some confidence as a result of access to this memo. *Stenopora tasmaniensis* is embedded in a 'coarse calcareous shale, or a grey limestone' ('*Geological Observations* . .', p. 162), and is associated with *Fenestella internata* which also occurs in a 'coarse grey calcareous shale, . . . splintery limestone . . . hard-ferruginous or light-coloured claystone' (*ibid,* p. 166). This association of fossils and rock types is best met in the limestones and siltstones of the Bundella Mudstone at Porter Hill, and, before the existence of Darwin's memo was known, the late Edith Smith had chosen this area on the basis of the associations as the locality from which neotypes should be set up. Not only are these fossils abundant at Porter Hill, but so also is *Fenestella ampla; Fenestella fossula* also occurs there. The matrix of *F. ampla* as noted by Lonsdale ('*Geological Observations*', p. 165) can also be matched at Porter Hill. This leaves only *S. ovata* and *Hemitrypa sexangula* of those species described by Lonsdale unlocated, but Lonsdale's description of the matrix leaves no doubt that Porter Hill was the site. *Stenopora ovata* occurs there but is less common than *S. tasmaniensis* at that locality. *H. sexangula* has not been recognised subsequently. Strzelecki also collected Permian fossils from Tasmania, which were described and illustrated by Lonsdale (polyzoa) and Morris (molluscs and brachiopods). These included a *Stenopora ovata* from Norfolk Plains (B.M.N.H. PD 4604), and *Stenopora informis* (B.M.N.H. PD 4605). Lonsdale took this opportunity to figure some of Darwin's specimens as, *Hemitrypa sexangula, F. fossula* and *F. ampla* (Strzelecki, pl. ix, f. 4a, 1a, 3) were stated to be from Darwin's collection (Strzelecki 1844, p. xvii). Morris also figured some Darwin material, e.g. *Spirifer tasmaniensis* Morris var. (Strzelecki, pl. xv. f. 4). Morris further stated *(ibid,* p. 280) that he had seen Darwin's specimens assigned *to Spirifera rotundata* and *Spirifera trapezoidalis* var. by Sowerby and he grouped them as *Spirifer tasmaniensis.*

Of the species based on Darwin's collections, specimens of only two are now available (*Productus brachythaera,* B.M.N.H. B 19298, which is a *Strophalosia,* and *Spirifera vespertilio,* B.M.N.H. B 10858). A neotype has been established by Crockford (1941) for *F. fossula* from near the top of the Cascades Group on Huon Road not far from the Turnip Fields and a specimen (B.M.N.H. PD 4603-5) exists of *Stenopora ovata* which was used and figured by Lonsdale in his work of Strzelecki's collection. It does not, however, come from the type area as deducible from Darwin's published and unpublished work.

Maxwell (1956) successfully suggested suppression of *Producta brachythaera* Sowerby (G.B.) 1844 in favour of *P. brachythaerus* Morris 1845 which then becomes the type of *Terrakea Booker* 1930, the type specimen of which was designated as B.M.N.H. BB 9466 from Illawarra. We thus now have the interesting situation that *Terrakea brachythaera* (Morris) occurs in the likely type area for *P. brachythaera* Sowerby.

Establishment of neotypes, where necessary, should be based on specimens from the Barossa Road area for *Spirifera subradiata,* at Eaglehawk Neck for *S. avicula* and from Porter Hill for the polyzoans, as suggested by the late Edith Smith in her manuscript on fossil polyzoa.

DARWIN'S CONTRIBUTION

Darwin recognised 'two distinct formations' near Hobart and a third further afield. The younger of the two 'formations' near Hobart contained rocks now known to be Triassic (memo p. 1 and top of p. 2) as well as Tertiary rocks (memo bottom of p. 2 and p. 3). He correctly (memo p. 5) correlated the coal-bearing Upper Triassic rocks of the Saltwater River area near Port Arthur with those of New Town. Some of the 'disturbances' in the Triassic on the Domain were correctly identified as cross-bedding.

The older 'formation' had 'hard sandstone' at the top (memo p. 6) which is now known to be Triassic and correlatable with the sandstones of Knocklofty and the Domain. Darwin himself almost made this correlation (central part of memo p. 6). The rock types beneath this sandstone, now regarded as Permian, were recognisably described by Darwin who also placed them in approximately correct superpositional order. He did not display any extraordinary virtuosity in noticing the great variety of fossils in the Permian rocks but perhaps this is not unexpected as he had only a hand lens and a simple microscope (up to about × 30; made by Bancks & Son, 119 New Bond Street; J. Dobson *pers. comm.*) with him and the state of palaeontology at the time was such that discrimination of the great variety of fossil forms was just beginning (the name 'palaeontology'

was used for the first time only in 1834 (Zittel 1901, p. 363) and it is doubtful if Darwin saw it before he reached England late in 1836). One might be amazed that a biologist and palaeontologist as good as Darwin could not provide better names than 'corallines,' 'Retepora,' 'Terebratula,' 'Pecten,' 'oysters' for the abundant Permian invertebrates he must have seen. However, it was only two years before Darwin left England in the 'Beagle' that the Polyzoa were recognised as fundamentally different from corals. As late as 1818 Lamarck recognised only three brachiopod genera, *Orbicula, Terebratula* and *Lingula,* and it was only in 1834, two years after Darwin left England, that von Buch published the first significant treatise on brachiopods (Zittel 1901, pp. 397, 399). Darwin did use the fossils and rock types to correlate correctly Permian rocks at Quamby Bluff with those at Hobart and elsewhere in south-eastern Tasmania.

He used the pebbles of Permian fossiliferous mudstone and Jurassic dolerite in the Tertiary beds at Sandy Bay to infer the correct order of deposition of his 'modern' and 'older' formations. The pebbles in the Permian he also used correctly to suggest the presence of older formations including the Precambrian quartzites with quartz veins in south-western Tasmania (memo p. 10, p. 20). Darwin noted (in his notebook marked 'R.N.', on p. 21; a zerox of which was kindly made available by Miss Dobson, Curator of the Darwin Collection) *'There is a resemblance at Hobart Town between the older strata and the bottom of the sea near T. del Fuego'.* In 'Observations on South America' Darwin commented (Darwin 1846) on the occurrence of pebbles on the sea-floor off the coast of southernmost South America and explained them as due to ice transport. Thus he seems to have visualised the possibility that the pebbles in the Permian (older strata) were ice-berg rafted. His reconstruction of the Permian ('second series') palaeogeography (middle part of p. 20 of memo) is remarkably close to much more recent attempts (e.g. Banks 1962).

Darwin's comments on the igneous rocks he saw were astute. He had an eye for unusual minerals and remarked on the red (?) olivine at Sandy Bay, subsequently recognised as iddingsite. He was probably the first observer to notice the pegmatitic or granophyric differentiates of the dolerite which he referred to as 'syenite', 'syenitic' and having 'aspects of a Granite' (memo p. 4, p. 12, p. 13), and to notice the syenitic appearance of dolerite weathered in some conditions. His identifications of minerals in the dolerite would not gain him a pass in a modern examination but must again be taken in the context of contemporary knowledge. Thus his identification as hornblende (instead of as augite) of the dark component in the greenstone (memo pp. 12, 13) reflects the common idea of the time that augite occurred only in volcanic rocks (after Haüy) and that hornblende occurred in 'compound and aggregated rocks' (Bakewell 1819, pp. 292, 301, 302).

On one important point Darwin's memo and his report on Van Diemen's Land published in *'Geological Observations'* differ. In his memo Darwin correctly deduced that the 'greenstone' (dolerite) was younger than the 'second series' (Permian and basal Triassic) on the basis of lack of dolerite pebbles in sediments immediately adjacent to the dolerite and the disturbance of the stratification close to the dolerite (memo. p. 10). Had he elaborated this argument in the published work, the debate which developed later on the age of the dolerite might well have been avoided.

Darwin saw or understood few of the many faults which affect the Hobart area (see map, Banks *et al.* 1965) but this perhaps is not surprising in view of the shortness of his stay and the probable lack of outcrop at the time.

On matters of geomorphology, Darwin noticed incidentally but did not interpret the accordance of summit heights (memo. p. 13) and gave much of his attention to recent changes in sea-levels (memo pp. 17-20). His observations on this matter were accurate but his argument confused and weak and one almost gets the impression that his interest in the subject developed so strongly and well in South America had overruled his discretion.

From his own observations and from discussions with Frankland and perhaps by judicious reading of the available literature on the geology of Tasmania, Darwin deduced a reasonably accurate geological history (memo pp. 20, 21) and some accurate palaeogeographic reconstructions. His suggestion of parallelism in history with New South Wales was perspicacious, that with New Zealand poorly founded.

When the statement on Van Diemen's Land in *'Geological Observations'* is compared with the memo, it is seen to be much less detailed and in places, e.g. where dealing with the 'modern formation', the condensation leads to confusion. Localities cannot be established with confidence. The locality for the leaves seen by Robert Brown had not been given in as much detail and led Johnston to infer incorrectly that they came from Geilston. Much of the material on the dolerite was reduced or eliminated although a new mineral identification, that of Hypersthene was added, presumably as a result of testing before the blowpipe, as fusibility is one of the tests given by Bakewell (1819) for distinguishing hypersthene from hornblende. Identification of the fossils he collected allowed Lonsdale and Sowerby to suggest affinities with the Mountain Limestone (Carboniferous) of Great Britain, a remarkably good correlation at that time. The published treatment of movements in sea-level was better organised and gives less impression of special pleading than does the memo. Thus, on the whole, the published work is less informative than the memo and it is regrettable that the latter was not published.

There remains the question of what Darwin, by his publication on Van Diemen's Land, added to knowledge of the geology. Before his visit scattered observations, especially about the coastline, had been made by early French and English exploratory maritime surveys, with a limited number of observations inland by early surveyors such as Humphrey, Laycock and Hellyer. Granite, basalt, sandstone, shale, coal and limestone, quartzite and slate had been recognised and minerals such as jasper, cornelian, quartz, hematite, silver lead, asbestos and feldspar recorded. Some comments on rock and mineral distribution were given by Bischoff (1832), a work certainly sighted by Darwin as he cited it in the Journal (p. 533). With minor exceptions, no relation-

ships had been established and no ages were known. A geological map of Van Diemen's Land drawn in 1836 would have been a mineral and rock-type distribution map. All earlier observations seem to have been made through Wernerian eyes; Darwin was the first Huttonian to do any geology here.

Darwin provided a more detailed description of the rocks within a small area in Tasmania than had earlier authors. He described for the first time variations within the dolerite. He also described, probably for the first time in Australia a structure of the type later called a 'Neptunian dyke.' His analytical techniques, though primitive, were better than those generally used earlier on Tasmanian rocks. But his work went beyond description and analysis. He concerned himself with relationships, a thing few if any earlier workers had done. He tried to establish a sequence as can be gathered from his published statement and even better from his unpublished memo. He collected fossils, not as curios but as means of correlating strata with those in Europe. His initial age determinations (see *Journal* and *Narrative)* were fair first approximations improved by more detailed work on the fossils by Lonsdale and Sowerby. Darwin inferred on relationships near Half Moon Bay that it had been the site of a volcanic crater, thus going beyond Péron who may earlier (1907, p. 247) have seen the basalt and scoria there. He would appear to have been the earliest author to note accordance of levels in Van Diemen's Land.

Thus Darwin's published work marked a considerable advance on any earlier work here and was a distinct contribution, but was overshadowed, unjustly, almost as soon as it was published by Strzelecki's monumental 'Physical Description . . .' Publication of Darwin's manuscript on Hobart would have been an even greater step forward than that provided by published material.

The reason or reasons for lack of publication of the manuscript is unknown. The published version is much abridged when compared to the manuscript and pressure of space may be surmised as one reason.

SUMMARY AND CONCLUSIONS

As a result of the location of the unpublished manuscript by Charles Darwin on the geology near Hobart, it has been possible to account for much of his stay of 13 days at Hobart in February 1836. The manuscript with associated specimen numbers allows localisation of his collection with considerable confidence. Polyzoa collected by Darwin and described by Lonsdale almost certainly came from the mudstone and limestone of the Bundella Mudstone on the shoreline at Porter Hill, Lower Sandy Bay, and the brachiopods described by Sowerby from the Darwin collection probably came from limestones of the Cascades Group near Barossa Road, Glenorchy, and from siltstones of the Malbina Formation at Eaglehawk Neck. Darwin's observations were acute enough to allow recognition of the rocks and localities he described, but he, perhaps naturally enough, did not see or deduce any of the many faults which affect the Hobart area. His identifications of minerals, rocks and fossils were good in terms of the very limited instruments available at the time and considering the state of the science. He was the first to recognise the relative ages of the dolerite and associated sediments and to describe a volcanic nieck (and recognise it as such) from Tasmania. His correct deduction of the geological history of the island, at least in broad outline, indicates his own acuteness and some fund of geological knowledge of Tasmania prior to his visit. He seems to have been the first Huttonian to publish on Tasmanian geology; all earlier writers appear to have been Wernerians.

REFERENCES

AUBISSON DE VOISIN, J. F. de, 1819: *Traité de Géonosie.* Paris.

BAKEWELL, R., 1819: An Introduction to Mineralogy. Longman, London.

BANKS, M. R., 1962: Permian in Geology of Tasmania. *J. geol. Soc. Aust.,* **9, 2,** 189-215.

BANKS, M. R. & WILLIAMS, E., 1965: Eaglehawk Neck. In *Geological Excursions for A.N.Z.A.A.S. Tasm. Dept Mines,* 36-38.

BANKS, M. R. *et al.,* 1965: Geological Map of Hobart. In *Geological Excursions for A.N.Z.A.A.S. Tasm. Dept Mines.*

BARLOW, N., 1933: *Charles Darwin's Diary of the Voyage of H.M.S. Beagle.* Camb. Univ. Press.

BARLOW, N., 1945: *Charles Darwin and the voyage of the Beagle.* Pilot Press, London.

BEER, G. DE, 1963: *Charles Darwin.* Nelson, London.

BISCHOFF, J., 1832: *Sketch of the History of Van Diemen's Land.* Woodfall, London.

CRAIG, C., 1964: *Old Tasmanian Prints.* Foot & Playsted, Launceston.

DARWIN, C., 1839: *Journal or Researches into the Geology and Natural History of the Various Countries Visited by H.M.S. Beagle.* Colburn London.

DARWIN, C., 1844: *Geological Observations on the Volcanic Islands.* Smith Elder, London.

DAVIES, J. L., 1959: High Level Erosion Surfaces and Landscape Development in Tasmania. *Aust. Geogr,* **7,** 193-203.

DUPERREY, L. I., 1830: *Voyage autour du Monde sur la Corvette.* LA COQUILLE. Bertrand, Paris; Zoologie, tome II.

FITZROY, R., 1839: *Narrative of the Surveying Voyages of H.M.S.s Adventure and Beagle between the years 1826 and 1836.* Vol. 2. Colburn, London.

FLINDERS, M., 1801: *Observations on the Coasts of Van Diemen's Land, on Bass's Strait and its Islands and on parts of the coasts of New South Wales.* Nichols, London.

FRANKLAND, G., 1836: A Notice on Maria Island on the East Coast of Van Diemen's Land. *Phil. Mag.,* **9,** 496-7.

FRANKLAND, G., 1839: *Map of Van Diemen's Land.* Cross, London.

HILL, D., 1950: The Productinae of the Artinskian Cracow Fauna of Queensland. *Pap. Dep. Geol. Univ. Qd,* **3.**

JOHNSTON, R. M., 1888: *A Systematic Account of the Geology of Tasmania.* Govt Printer, Hobart.

LEWIS, A. N., 1946: *Geology of the Hobart District. Mercury,* Hobart.

MacCulloch, J., 1821: *A Geological Classification of Rocks, with Descriptive Synopses, comprising the Elements of Practical Geology*. London.

Maxwell, W. G. H., 1956: Proposed use of the Plenary Powers to designate a type species in harmony with the accustomed usage for '*Terrakea*' Booker (F.W.) 1930 (Class Brachiopoda). *Bull. Zool., Nomenc.*, vol. II, Pt II, pp. 333-6.

Peron, M. F., 1807: *Voyage de Découvertes aux Terres Australes*. Imperial Press, Paris.

Scott, T. H., 1824: Sketch of the Geology of New South Wales and Van Diemen's Land. *Ann Phil*, **7**, 462.

Spry, A. H., 1955: The Tertiary Rocks of Lower Sandy Bay, Hobart. *Pap. Proc. Roy. Soc. Tasm.*, **89**, 153-68.

Strzelecki, P. E., 1845: *Physical Description of New South Wales and Van Diemen's Land*. Longman *et al.*, London.

Sutherland, F. L., 1964: The Geology of the Collinsvale Area. *Pap. Proc. Roy. Soc. Tas.*, **98**, 119-35.

Waterhouse, J. B., 1968: The Classification and Descriptions of Permian Spiriferida (Brachiopoda) from New Zealand. *Palaeontographica*, A, **129**, pp. 1-94, pl. 1-18.

Zittel, K. A. von, 1901: *History of Geology & Palaeontology*. Scott, London.

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PALAEOZOIC ROCKS OF THE DAVEY RIVER SOUTH-WEST TASMANIA

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With seven text figures (commented by G. E. A. Hale)

ABSTRACT

A conformable succession in Palaeozoic rocks occurs at the Davey River at the southern end of the Olga-Hardwood syncline in S.W. Tasmania, and consists of the following formations (with approximate thicknesses):

(top)	Unit 6	Sandstone	10 metres
	Unit 5	Shale	15 metres
	Unit 4	Sandstone, minor shale, conglomerate	75 metres
	Unit 3	Shale-sandstone alternation	0-500 metres
	Unit 2	Pebbly sandstone	0-500 metres
(bottom)	Unit 1	Quartzite conglomerate	0-800 metres

Formations 1, 2 and 3 are equivalent, on lithological and structural grounds, to the Bathurst Harbour Sequence of Jennings (1961). Unit 4 has lithological and faunal similarities with the Caroline Creek Sandstone of the West Coast Ordovician succession (Banks 1962b). Equivalents of the Florentine Valley Mudstone and Gordon Limestone are probably also present in the centre of the syncline.

If these correlations are correct the Davey River succession provides a link between the Bathurst Harbour and West Coast successions, with the Long Bay Shale representing a marine formation which is present in the South-west but apparently absent on the West Coast.

INTRODUCTION

The Cambrian and Ordovician succession of Tasmania has been described by many workers and a regional consensus is presented by Banks (1962 a, b). The present paper describes a new, continuous and conformable Lower Palaeozoic section which suggests that there are rock units in the South-west which are not present in other parts of the State. The study was made at the southern end of the regional Olga-Hardwood Syncline near 400,000 yds E, 700,000 yds N, Tasmanian State Grid, where the Crossing River joins the Davey River. Figure 1 is a lithological map showing the distribution of the rock units, which are exposed on the valley sides and flanks of Piners Peak (in the west) and an unnamed range (on the eastern side). The centre of the syncline, by analogy with the northern end of the same structure, is thought to be occupied by Gordon Limestone, but formations above Unit 6 are not exposed.

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STRATIGRAPHY

Unit 1

Unit 1 is a massive, close framework quartzite conglomerate of variable thickness that unconformably overlies Precambrian basement in the headwaters of Badger Creek. The unit also occurs on the western side of the syncline, on the eastern slopes of Piners Peak. It contains angular to sub-rounded pebbles and boulders of milky quartzite and quartz-schist which make up to 90% of the rock and range in size from 1 cm. to 50 cm. (average 5 - 10 cm.). The matrix is of granule size angular fragments of white quartz. Figure 2 shows the composition of 21 different outcrops.

At the head of Badger Creek, a crude, very-thick bedding is marked by the orientation of pebble long axes, segregation layers based on pebble size and composition, and minor lenses of matrix. The thickness of the unit varies from 800 m. on Piners Peak to zero in many places.

The unit is post-Precambrian, overlying basement with a marked angular unconformity. Various boulders contain fold hinges and other structures representative of the major tectonic events in the Precambrian of the Davey River. (Maclean and Bowen, in preparation). No fossils were found.

The local source of rocks is joint blocks from subjacent bedrock, the general texture and sedimentary fabric and lack of marine influence suggest the deposit is a terrestrial fanglomerate.

Unit 2

Unit 2 is a siliceous, open framework, pebbly conglomerate that conformably overlies Unit 1 in the headwaters of Badger Creek. It contains 10-25% subangular to rounded ellipsoidal pebbles of milky quartzite in a sand to granule size matrix of quartz grains, with

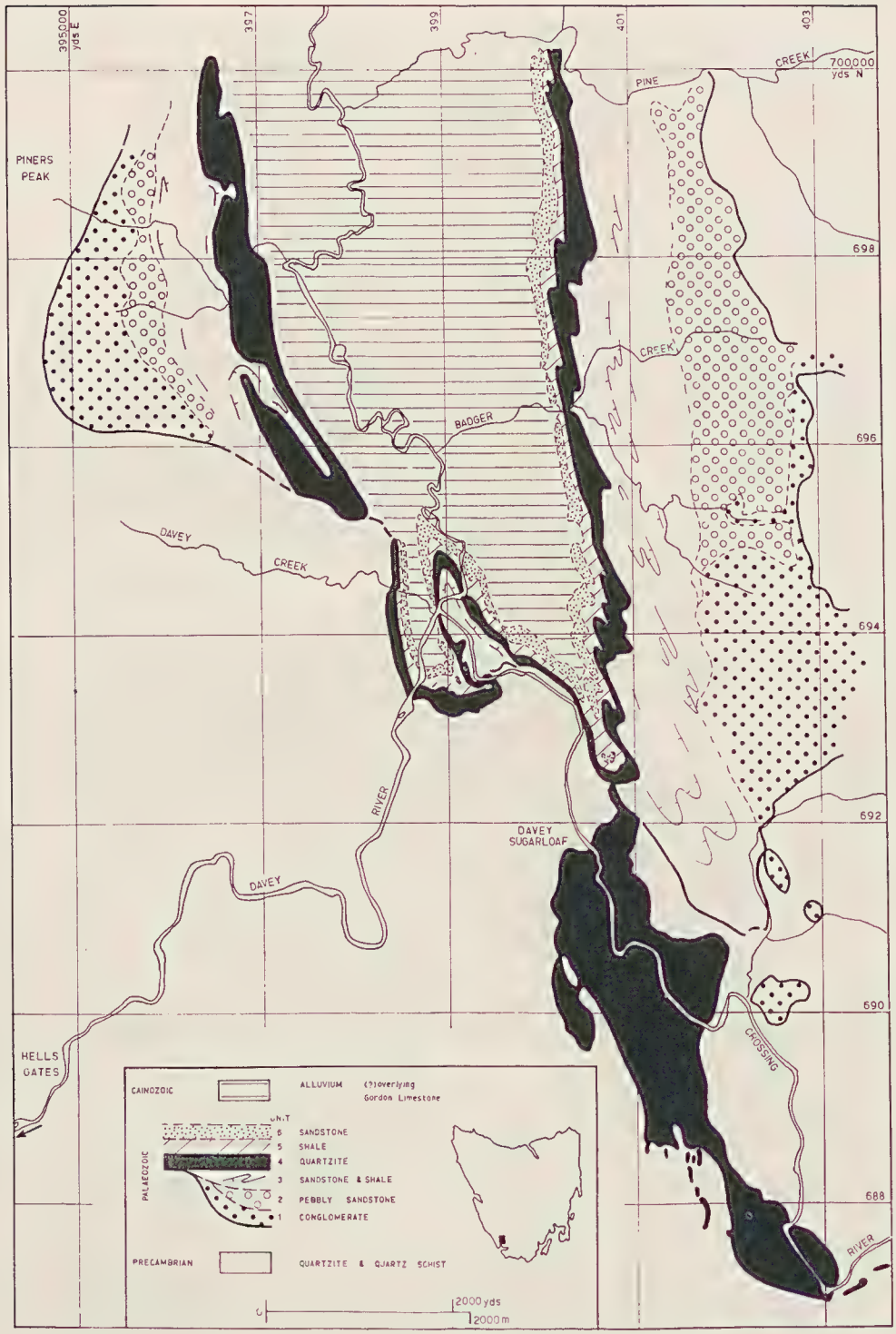

Fig. 1.—Lithological Map of the Davey River Area, with Tasmanian State Grid Co-ordinates.

a range of compositions as shown by the heavy black area of Figure 2. The pebbles range in size from 0.5 cm. to 12 cm., with an average of 3 cm.

Fig. 2.—Triangular diagram showing the composition of 21 typical outcrops of Unit 1 (black dots), and the range of composition of samples from Unit 2 (dark area).

The unit has a crude bedding (45-60 cm. thick) defined by internal features such as weak grading, pebble layers and occasional silty layers showing planar and festoon cross-bedding. The pebbly sandstone rests conformably on Unit 1 with a distinct boundary. Thickness of the unit varies from zero to 500 m.

The matrix of Units 1 and 2 is similar in size and composition, but Unit 2 differs in that the framework is open, the pebbles are generally rounded and the less resistant types are not present. Units 1 and 2 have the same source area but Unit 2 has been deposited by a different transport mechanism, probably as a fluvial wash derived from Unit 1.

The isopach map of Figure 3a indicates that Units 1 and 2 form an east-west trending lens which thins to the north and south of Badger Creek. The northern and southern boundaries of the outcrop are probably close to the boundaries of the original sedimentary basin.

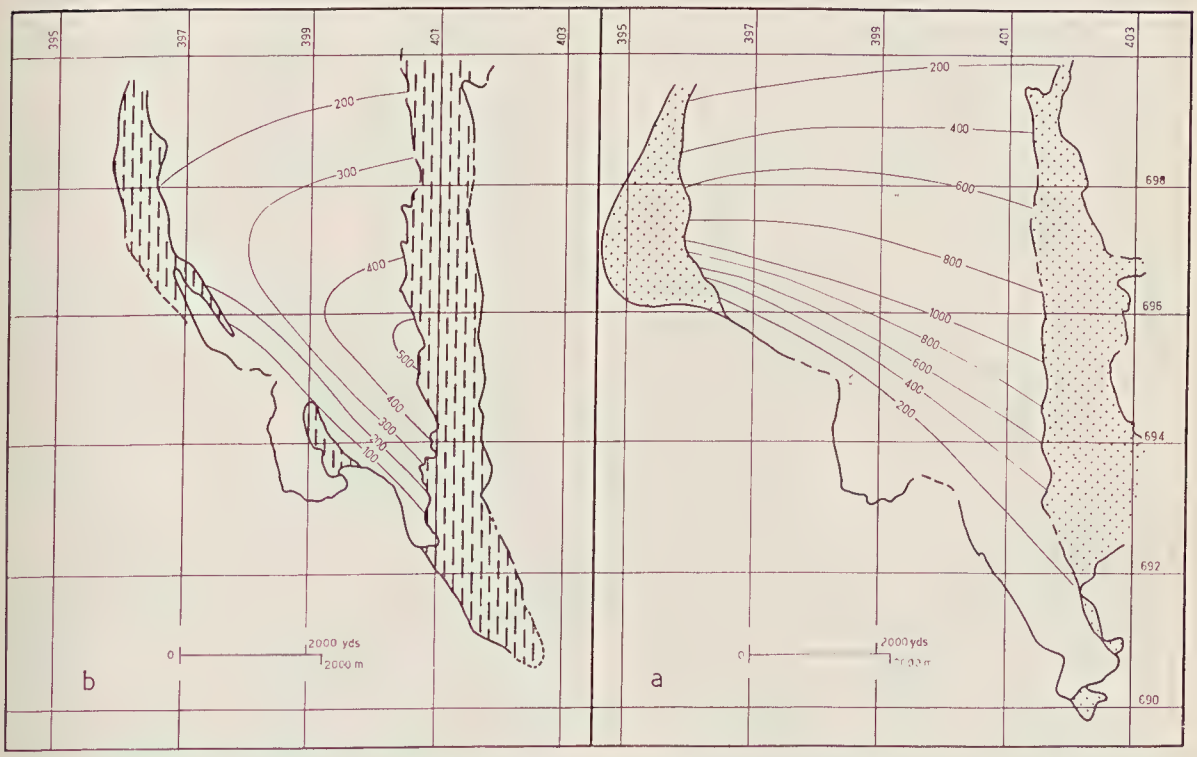

Fig. 3.—Isopach maps showing the shape and trend of the depositional basin. Figure 3a is for Units 1 and 2 combined; formline interval 200 m. Figure 3b is for Unit 3, with formlines at 100 m. intervals.

Unit 3

Unit 3 is a poorly exposed, topographically negative sequence of well-bedded sandstones and shales that conformably overlies Unit 2 in Badger Creek and outcrops as shown on the lithological map (figure 1). The top 125 m. of the unit at Badger Creek is a monotonous alternation of sandstone and siltstone beds and although the remainder of the sequence is poorly exposed, the limited outcrop suggests it is similar in character.

The sandstone beds range in thickness from 5 cm. to 1 m. with occasional beds up to 3 m. thick in the lower part of the sequence. Grainsize varies from fine to coarse sand. Many beds are graded and some contain up to 30% rock fragments. A secondary mica foliation gives the sandstones a well marked cleavage and those near the top of the sequence often contain scattered pyrite cubes up to 2 mm. in width.

The shale beds are finely laminated and generally grey or green in colour. Beds range in thickness from 5 - 125 cm. and average about 20 cm. The shale has a well developed slaty cleavage with secondary mica on the foliae. Some siltstone beds near Badger Creek have a primary detrital carbonate content.

The isopach map of figure 3b shows Unit 3 as an east-west oriented tongue thickening eastwards and thinning north and south from a maximum of 500 m. in the vicinity of Badger Creek. The boundary with the overlying Unit 4 appears to be conformable in Badger Creek, and over a wide area the bedding in Units 3 and 4 is not discordant, as shown by the stereogram in figure 4.

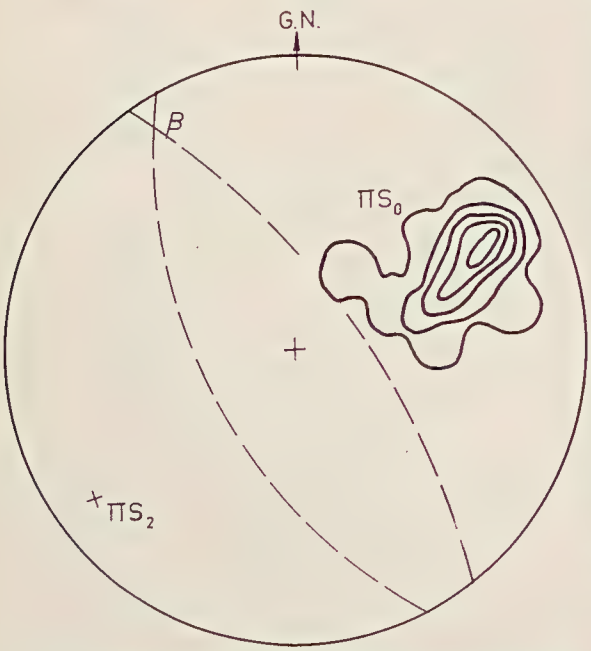

Fig. 4.—Stereogram of 50 poles to bedding (S_0) from near the boundary of Units 3 and 4 at Badger Creek. Contour interval 10% mode 48% at 26-062.

The unit resembles a turbidite sequence and is restricted to the same basin of deposition as Units 1 and 2. It contains no fossils, and sedimentary features include load casts and grooving. The mica foliation is due to low grade metamorphism and is equivalent in grade to the silicification of Unit 4 (see discussion under Unit 4).

Unit 4

Unit 4 is a sequence of bedded shales, quartzose, sandstones and conglomerates containing fossils and organic markings, which rests conformably on Unit 3 in Badger Creek. In places where Unit 3 is absent, Unit 4 rests unconformably on Precambrian basement. The thickness of the unit is consistently about 75 m., but the lithology changes markedly away from the source of sediment.

The sandstones and conglomerates have recrystallised and often resembles meta-quartzites. Petrological examination indicates the rocks were: 1) laid down as quartz clastics, 2) recrystallised to quartzites by the addition of intergranular quartz, and 3) weathered at the surface causing the grain boundaries to be etched and restoring the clastic appearance. The rocks consequently appear massive and structureless on fresh surfaces but the sedimentary features become obvious on weathered outcrop. Many samples possess a slaty, or possibly, a very fine crenulation cleavage. Quartz grains often have undulose extinction and contain deformation lamellae. It is assumed these features formed during the Tabberabberan deformation of these rocks and that similar features in Unit 3 probably have the same origin.

In fine-grained beds, or in the silty tops of graded beds there are abundant organic markings. These include gastropod and ribbed bivalve casts, worm trails and burrows perpendicular to bedding. Sedimentary features include ripple marks, mud cracks and festoon and planar crossbedding. Current direction was towards the south and east.

The composition of individual beds and the bulk composition of the unit varies systematically from west to east, localities A to C, as shown in figure 5. In the Piners Peak area (locality A), about 30% (in particular the basal part) of the Unit consists of open and closed framework, subangular, quartzite conglomerate. Locally a roundstone conglomerate is often dominant. These conglomerates resemble Unit 1 in lithology, but are here closely associated with the more varied lithology and fossil horizons characteristic of Unit 4. The components were derived from the same source as Unit 1. A further 60% is medium to coarse grained sandstone with occasional subrounded to rounded quartz pebbles. The silty fraction is minor and restricted to the fine grained tops of some sandstone beds. Such beds often contain mud-cracks, in other cases, fossil markings.

Near the junction of the Davey and Crossing Rivers (area B), the unit is 20% granule and pebble conglomerate in beds 10 - 20 cm. thick. The pebbles are generally rounded, ellipsoidal shapes which lie parallel to bedding. About 60% of the unit is composed of fine to coarse grained sandstones which often contain scattered pebbles. Near the top of the unit is a mudstone bed 60 cm. thick and a few fossiliferous horizons.

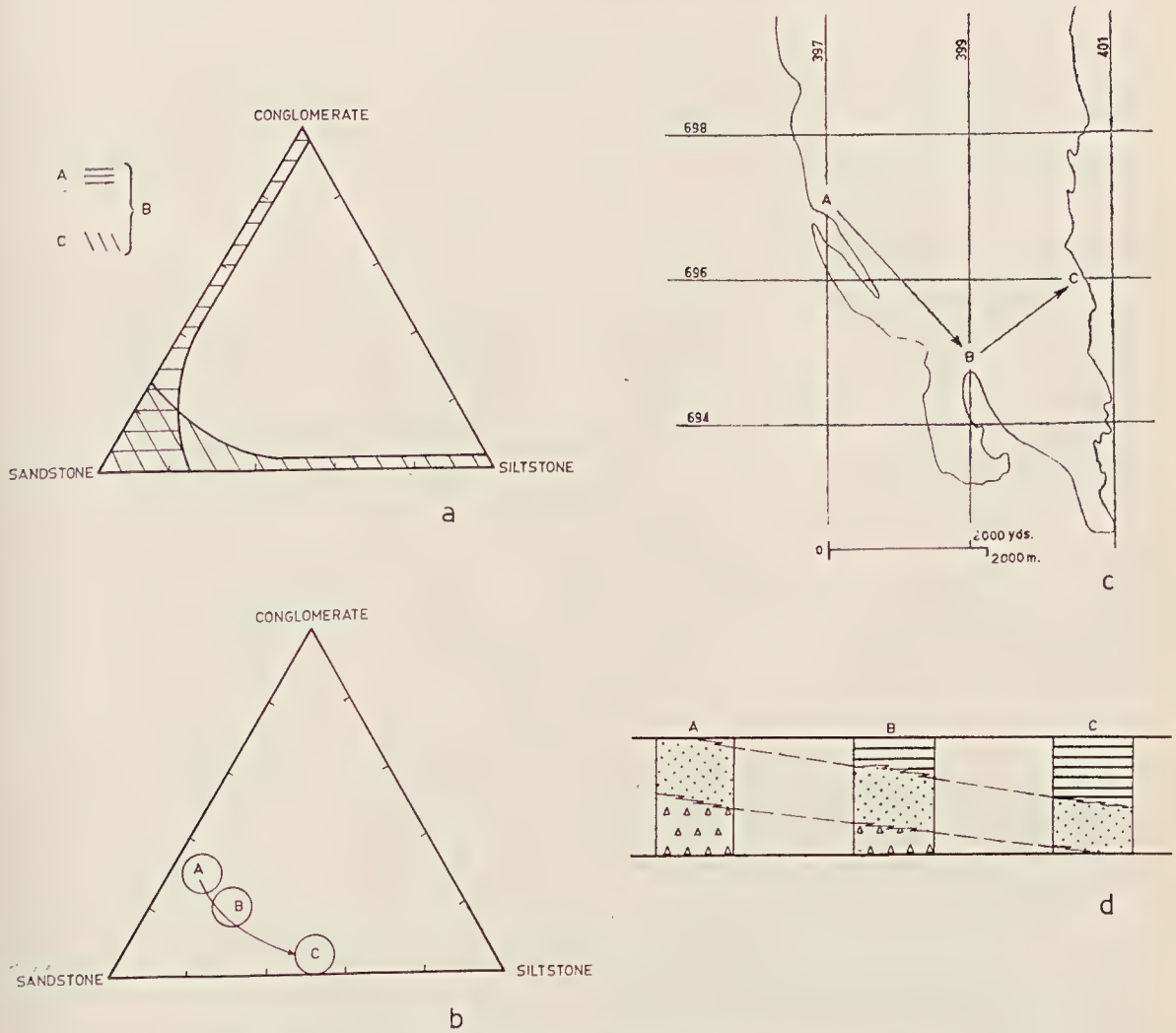

Fig. 5.—Variation in the composition of Unit 4 between localities A, B and C.
(a) range of composition of beds at each locality.
(b) bulk composition of Unit 4 at each locality.
(c) locality map.
(d) summary of the lithological change in Unit 4 across the basin.

In the Badger Creek area (locality C), the Lower half of Unit 4 is a fine to coarse sandstone with granule bands and occasional rounded quartzite pebbles. Beds range in thickness from 30 cm. to 5 m. and are often haematite stained. The upper part of the sequence consists of beds of silt and fine sand with some scattered milky quartzite pebbles. The tops of some beds are highly fossiliferous and contain gastroped casts, worm trails and tubes.

Figure 5 is a diagrammatic summary of the way in which the composition of Unit 4 varies from west to east. Conglomerate becomes less important in the east, the silty fraction increases while the sandstone percentage remains about constant. Although the facies changes quite markedly away from the source of the sediment in the west the unit is quite distinctive and easily identified in the field. Unit 4 overlaps Units 1, 2 and 3 and is transgressive onto Precambrian basement as indicated on the lithology map (figure 1). The unit has a strong lithological and faunal resemblance to the shallow water marine Ordovician Caroline Creek Sandstone and its correlates as defined by Banks (1962b).

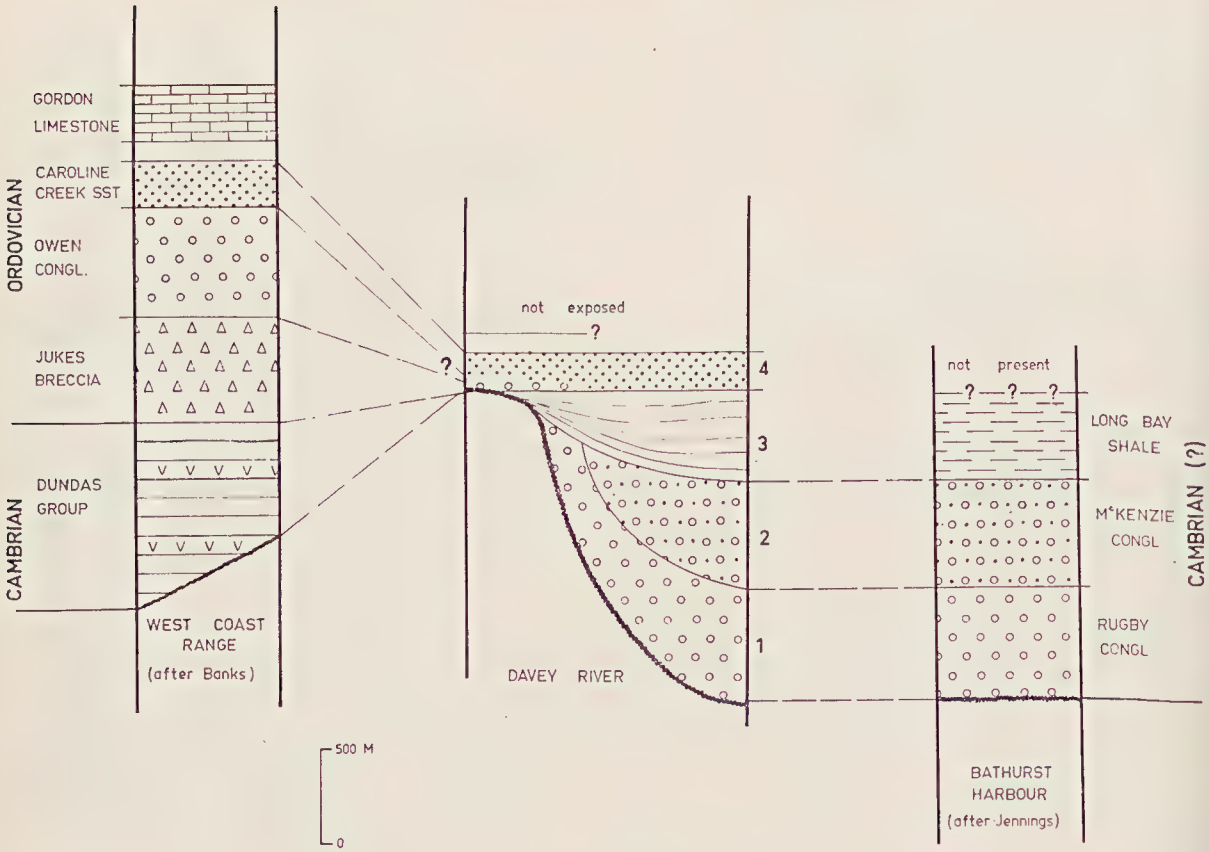

Fig. 6.—Possible correlation of the Davey River sequence with the Bathurst Harbour and West Coast Range successions.

There are scattered outcrops of conglomerate to the S.E. of the Davey Sugarloaf that may belong to this unit. The conglomerate has a closed framework and occurs as discontinuous plates up to 5 m. thick resting directly on Precambrian quartzites. Close to basement it is a breccia formed by the slight disorientation of joint blocks in the underlying rocks, but upwards, the boulders are more rounded and occasional imbricate roundstone conglomerates are present. In this paper the conglomerate is considered the basal member of Unit 4 and is identified with the basal conglomerate in Unit 4 at Piners Peak. It could, alternatively, be considered as a limited expression of Unit 1 on the basis of lithology and its unconformable boundary with Precambrian basement.

Formations Above Unit 4

Immediately overlying Unit 4 is a poorly exposed shale up to 15 m. thick. It has a strong negative topographic expression and is shown on the lithological map (figure 1) as Unit 5. Above this is about 10 m. of friable, argillaceous, white sandstone in beds 7 - 30 cm. thick which is shown as Unit 6 on figure 1. The section above this is not exposed but is assumed, from the mapping of Hall (pers. comm.) and work on the Olga Dam site (Hale, pers. comm.), to be Gordon Limestone.

CORRELATION

Unit 4 is a distinctive horizon and is identified with the Caroline Creek Sandstone (Banks, 1962b) on the basis of lithological and faunal similarities. This is shown in both figures 6 and 7. Units 5 and 6 may also belong to the Caroline Creek Sandstone, or may be equivalents of the Florentine Valley Mudstone (Banks, 1962b). The formations above Unit 6 are not exposed but the regional mapping of Hall (pers. comm.) makes it probable that Gordon Limestone occupies the centre of the syncline.

The lower part of the Davey River section may be equated with the Bathurst Harbour sequence of Jennings (1961), on the basis of lithology, sequence and proximity. Figures 6 and 7 show Units 1, 2 and 3 equivalent to, respectively, the Rugby, McKenzie and Long Bay formations of Bathurst Harbour in lithology and position in the sequence.

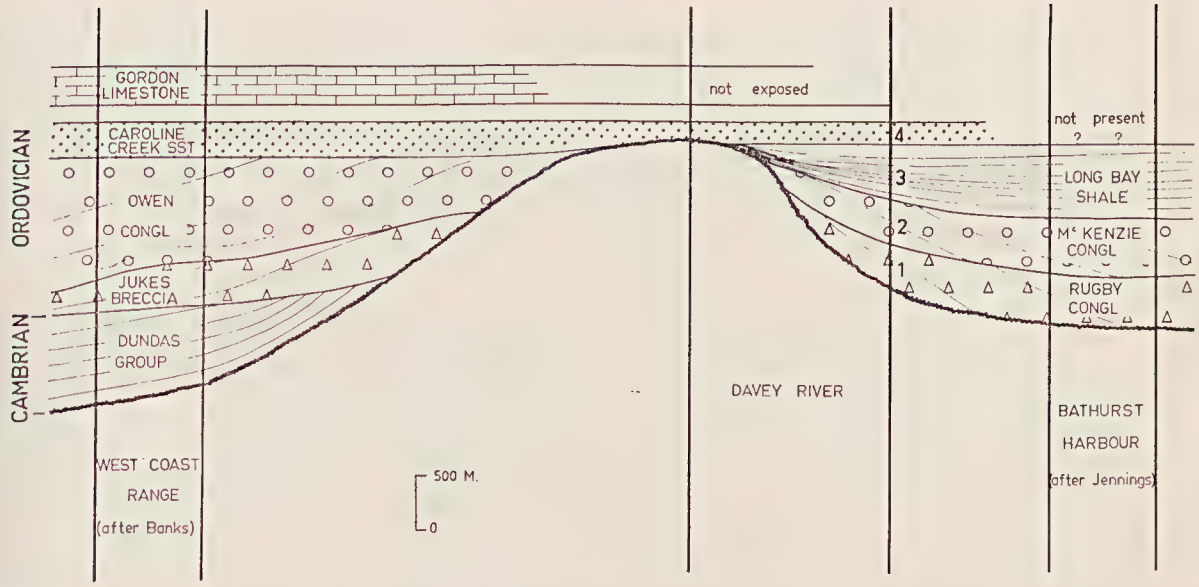

Fig. 7.—Correlation between the Davey River, Bathurst Harbour and West Coast successions, showing the separate depositional basins.

The Davey River succession, if these identifications are correct provides a link between the Bathurst Harbour and West Coast sections. The mapping of Hall (pers. comm.) and Stefanski (reported in Jennings 1961, p. 182) suggests that equivalents of the Caroline Creek Sandstone are probably also present in the Bathurst Harbour and Ironbound Range areas of S.W. Tasmania.

The time relationships between the Davey River and West Coast successions is open to conjecture. Jennings (1961) gave the Bathurst Harbour succession a probable Cambrian age, but pointed out the marked lithological similarities between the Rugby Conglomerate and the Owen Conglomerate of the West Coast Range. Hall (pers. comm.) has alternatively assigned the Davey River Units 1 to 3 to a Younger Proterozoic 'Bathurst Group', on the basis of structural differences between Units 3 and 4 which are suggestive of a major unconformity between them. Intensive mapping at the Davey River has found no evidence of a stratigraphic discordance, and in this region the passage from Unit 3 to 4 is considered to be conformable. Apparent differences on the air photographs in structural style between Units 3 and 4 are found in the field, and in thin section, to be due to differences in lithology and not significant differences in deformational history.

Using the lithological identifications made earlier, it is possible to correlate the Port Davey succession in either of two ways. The first alternative, shown in figure 6, is to assign everything below Unit 3 to the Cambrian so that any similarity between the Rugby and Owen Conglomerates is a similarity in provenance and depositional mechanism, and not one of age. The Owen and Jukes formations may possibly be represented by the conglomerate at the base of Unit 4 at the Davey River.

The second alternative shown by figure 7, is to regard the Rugby and McKenzie Conglomerates as time equivalents of the Jukes and Owen, and the Long Bay Shale as a rock unit which was deposited in the Port Davey area but which is not recognised on the West Coast. This correlation is regarded as more likely and a depositional history may be reconstructed on this basis.

The depositional basin in South-West Tasmania was separate from the West Coast Basin, which probably developed earlier and contains Cambrian Dundas Group sediments and interbedded lavas, as described in Banks (1962a). The basin in the South-West formed in the early Ordovician and large thicknesses of conglomerate accumulated, as they did in the West Coast Basin at about the same time. The Long Bay Shale finally filled the South-West Basin and may, or may not, have correlates in the West Coast Range succession. The deposition of Caroline Creek Sandstone followed and represents a marine transgression across both basins and the adjacent Precambrian basement.

CONCLUSION

The conformable succession of Long Bay Shale (top), McKenzie Conglomerate and Rugby Conglomerate (bottom) which occurs at Bathurst Harbour (Jennings 1961) and at the Davey River (this report) may be of Ordovician age in which case the Long Bay Shale represents a marine incursion apparently not present on the West Coast. Alternatively the Davey River and Bathurst Harbour successions may contain Cambrian formations although this appears extremely unlikely.

REFERENCES

BANKS, M. R., 1962a: The Cambrian System in 'Geology of Tasmania'. *Journ. Geol. Soc. Aust.* **9, 2,** 127-45.

BANKS, M. R., 1962b: The Ordovician System in 'Geology of Tasmania'. *Journ. Geol. Soc. Aust.* **9, 2,** 147-76.

JENNINGS, I. B., 1961: Notes on the Geology of Portion of South-West Tasmania. *Tas. Dept Mines Geol. Surv. Rept,* **5.**

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FOSSIL SHORELINES OF THE ULVERSTONE DISTRICT, TASMANIA

by

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ABSTRACT

The Ulverstone district covers part of the coastal lowlands of the North-West Coast district of Tasmania, centred upon the Leven River, some 12 miles west of the southernmost point on the Tasmanian shore of Bass Strait. A series of well marked older shorelines is found along and below the coastal escarpment. Included are shorelines at 110, 65, 45, 35, and 3 feet above mean higher high water mark, which, at Ulverstone, is 10 feet above State Datum. The highest shoreline is interpreted as representing a late high sea level of the Mindel-Riss Interglacial.

The 65 foot shoreline, the Ulverstone shoreline (45 feet) and the Glenhaven shoreline (35 feet) are interpreted as being Last Interglacial. The Glenhaven shoreline is associated with cobble material thought to be marine-redistributed glacifluvial material from the Forth river. It may constitute further evidence for two phases of Tasmanian glaciation.

The Brigadoon shoreline is thought not to require a rise in sea level to 3 feet to explain its morphology. Its age is interpreted as being Holocene. Benches on the sides of Buttons Creek and Claytons Rivulet are structural in origin, but fragments of valley fill terraces in the Leven valley are thought to be related to older shorelines. Parallels are drawn between landforms of the present coastline and landforms existing on fossil shorelines in the area and between fossil shorelines at Ulverstone and those elsewhere in Tasmania and King Island.

INTRODUCTION

The aim of this paper is to describe the form, and, where possible, the origin of the fossil shorelines in an area delimited by Claytons Bay in the east and the Three Sisters in the west. (See Figure 1). Detailed description of the morphology and sedimentology of the estuary and of the modern shoreline is reserved for future papers. Nomenclature used in this paper has the approval of the Nomenclature Board of Tasmania in part only. Reference to localities is made by the grid system of Zone Seven. Edwards (1941), Davies (1959) and Fish and Yaxley (1966) make passing reference to this district, and Davies (personal communication) has made a general reconnaissance of the area and a study of the Devonport Harbour to the east, but no significant work has yet been published on the geomorphology of the Ulverstone district.

Morphological Method

The writer accumulated hypsometric data from some 40 miles of levelling with dumpy level and theodolite and from published topographical maps. (Figure 3). All traverses were tied to bench marks based upon State Datum. Heights given in the text have been recalculated to height above mean higher high water mark at Ulverstone by subtracting 10 feet. The traverses were used to elucidate the system of marine terraces which exist below the old Pleistocene cliff line that truncates a dissected surface sloping from about 900 feet to about 250 feet. Far more traverses were completed than can possibly be included in the figures. However data derived from them are used to construct Figure 4.

Soil morphology

Careful observations were made of soil colours, textures and profile forms, using the key developed by Northcote (1965) in an attempt to differentiate between soils of the various terraces and slope deposits. 17 auger holes were put down to the depth of bedrock, cobble beds or the water table; 14 pits were dug and in addition to the recording of descriptive data in the field, 28 samples were collected for subsequent sedimentological analysis. Reference was also made to the diaries of the Municipal Clerk of Works which treat upon soil conditions relevant to the sewerage scheme. Since these data are very voluminous, reference will be made to them only where they appear to throw light on the age, morphology and/or genesis of the landform on which they are developed.

ABANDONED SEA CLIFFS

Location and Altitude

A scarp, generally in excess of 150 feet in height runs the full length of the study area at a distance between 50 yards and slightly over a mile from the modern coastline. Scarp slope elements vary between almost vertical and 9°30′, but are mostly less than 30°. The height of the base of the scarp is also variable between 3 feet above higher high water mark and about 55 feet, due to the truncation of parts of the fossil shorelines. Tests may also reveal strong positive correlations between increasing height of the base of the scarp and first, increasing thickness, age and degree of weathering of the wedge of detritus at the scarp foot, and secondly increasing distance from the coastline—that is, the width of the coastal terraces. Breaks in the cliff line occur only at the mouths of streams, where the scarp curves to follow the trend of the river course.

No clear distinctions between the morphology of valley sides and of abandoned marine cliffs were observed that could be ascribed to marine as opposed to fluvial agency. This may be due to the fact that, even as the sea has abandoned the cliff, the streams are aggrading their lower reaches so that the agents developing the slopes on valley sides and abandoned

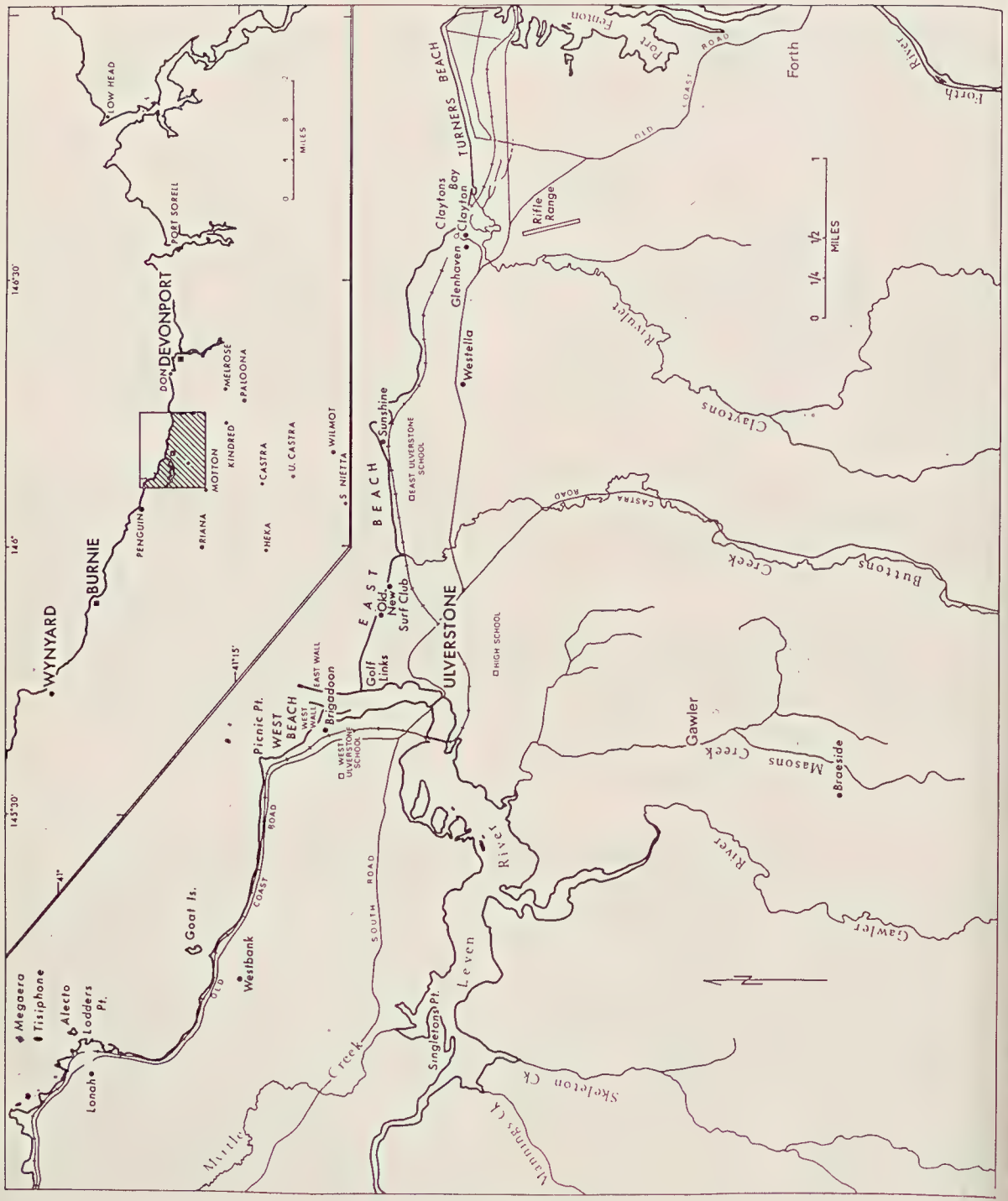

Fig. 1.—Location diagram.

marine cliffs have for some time been the same, viz. slope wash, surface creep, terracettes and slumping.

Mass movement

The efficacy of mass movement processes is due to the initial slope (variations in which are not ascertainable) and to the relative susceptibility of the rocks concerned. The more degraded scarps are found where the escarpment intersects a Tertiary deep lead such as that behind the old rifle range or just west of 'Westbank', where the heel of a landslip involving some 22 million cubic feet of material scallops the cliff line by some 200 yards. The bulbous toe spreads across the marine terraces below the cliff, to the sea's edge. The surface of the slide still preserves the reverse slopes diagnostic of rotational slip. This landslip clearly postdates recession of the sea from the cliff line. Other slides, such as that east of 'Westella', preserve scarce trace of such surface features and are clearly far older. Where man has sharpened the scarps, south of 'Lonah', and on Westbank Hill, rockfalls occur after heavy rain. Apart from very minor slumping on these landslips, there is very little evidence of active mass movement today.

The Clayton and Button Terraces

On the west bank of Claytons Rivulet at 198294 and on the east bank of Buttons Creek at 172275 are prominent valley side benches at 170 and 240 feet respectively. They are about 150 yards wide. There appears to be no clear evidence that these benches are matched by any other on the opposite bank of the streams, neither do they persist for more than about 3000 yards downstream, nor are their heights represented by any prominent level in the thalwegs of the streams, which are at or close to grade, or by any corresponding benches along the old marine cliffs. In each case, however, the bench represents a change in lithology from Tertiary rocks of the upper sequence of slope units to Precambrian garnet schist comprising the lower sequence. Similar arguments for lithological control may apply to a dissected bench at about 140 feet above the Gawler, southwest of 'Braeside', developed on Rocky Cape Group metasediments.

Narrow marine benches

The bench at about 110 feet along the side of the old marine cliff at West Ulverstone is developed across both basalt and (further west and rather less clearly) across Rocky Cape Group rocks. It is thought unlikely that a landslip could develop this bench, as it is far too long, narrow and uniform in height. Nor do slope angles on it seem typical of landslips on basalt. Landslips on basalt were observed to be either deeper and longer than their width or to consist of a confused, even chaotic, complex of movements along a broad hillslope zone. Landslips (as opposed to rock falls) were not noted at all in Precambrian rocks. No sediments were found on this bench other than a wedge of surface wash from the slope above.

The prominent bench at 55-65 feet in the township proper does have some sediments: grits, clays and silts, particularly towards Buttons Creek along the line of Castra Road. It is also represented at 'Lonah', perhaps by the summits of Goat Island, a ledge on Westbank Hill, and, rather more tentatively it is believed that South Road crosses a bench at the same height. Nowhere were the sediments found to bear much resemblance to marine sediments, though there is an unconfirmed report in the neighbourhood of shell beds at the east end of Leven Street.

The remaining surface features of the coastal zone consist of a flight of very gentle step-like features from 44 or 45 feet down to a pronounced scarp, the base of which is 3-4 feet and which varies from 3-8 feet in height. Three old shorelines can be distinguished within this altitudinal range on the bases of height, surface morphology and soil development.

THE ULVERSTONE SHORELINE

Even the existence of the sewerage scheme maps, contoured at 5 feet intervals and with tens of thousands of spot heights was of little use in distinguishing the fine detail of the surface morphology of the terrace system within the town area, particularly where home and street development are concentrated. Careful observation after heavy rain was more useful, enabling the writer to pick out the swales of lower relief and waterlogging from the intervening swells.

The Ulverstone terrace is defined to be the almost featureless surface below the Ulverstone shoreline which is at 45 feet. (See Figure 6). An almost imperceptible swale, parallel to the line of the hill behind runs towards Buttons Creek in the east and Masons Creek in the west, the latter section being better developed along Alexander Street. There are possibly two parallel swells. East of Buttons Creek the terrace continues as far as 'Westella' where it pinches out. The terrace is not entirely depositional in character as the house west of 'Westella' at 179309 is built on a basalt bench which stands at 40 feet, 1.5 feet above the sandy terrain. Trenching during the implementation of the sewerage scheme revealed a variable A horizon of bleached grey fine sand, underlain by a pronounced hardpan of coffee rock, up to 20 feet thick, which is so indurated that it required blasting in places. This is underlain by flowing sand, shell or shingle beds at depth, except near Buttons Creek where the proportion of clay increases markedly.

THE GLENHAVEN SHORELINE

The Glenhaven shoreline is at 35 feet. To seawards is a system of from 3-9 parallel to semi-parallel fossil dune ridges and intervening swales which lie below 35 feet in the main and terminate seawards at the scarp backing the Brigadoon beach ridge system. East of 'Westella', only a narrow strip of land lies above 35 feet between the Glenhaven fossil dunes and the old cliff line. It consists of a mixture of slope wash and marine terrace material, often with basalt floaters. Since it lacks both the soils and the morphology typical of the Ulverstone Terrace it is here considered to be associated with the Glenhaven Shoreline.

Post Glenhaven shoreline depositional landforms are narrowest southwest of Goat Island, where there is no fossil dune development, merely a narrow raised beach of coarse to medium texture grey sand. Between Westbank Hill and Picnic Point seawards of the Glenhaven shoreline are three sub-parallel fossil dune ridges with intervening raised beach sediments, lying thinly over reefs of Precambrian and Cambrian rocks at a higher

Fig. 2.—Contour map of the Ulverstone district, Contour interval = 50 feet. Datum = State Datum.

level than the reefs of the modern shoreline, but at approximately the same slope angle. In several places the reefs project through the dune and raised beach sediments, and there are numerous floaters of locally derived angular pebbles and boulders—features also typical of the beach immediately seawards. Towards Picnic Point the surface below the Glenhaven shoreline becomes more step-like, with raised basalt shore platforms at 25 feet.

The alignment of the fossil dunes between Westbank Hill and Picnic Point is sub-parallel to the cliff line. The dunes are closer together at the western end, where they consist largely of conglomerate pebbles of local origin, but become more widely spaced and sandier towards the east. This is the same disposition as the dunes of the modern coastline and of the fossil dunes in the type locality of the Glenhaven shoreline between 'Clayton' and 'Westella'. The basalt hill at 'Westella' acts as a fulcrum for the alignment of five of the fossil dunes. Figure 6 shows how the inner dune (30.58 feet) lies east-west, but that the fourth, which terminates at 'Glenhaven' and the fifth, which terminates at 'Clayton' have alignments parallel to the frontal dune of Turners Beach, and for the same reasons.

These five dunes are composed of sediments of two kinds. Surface layers are sandy, but at depth (surficial in the case of the inner dunes) there are cobbles. These are not of local origin. Their presence here and elsewhere along the coast constitutes a problem for which a solution is suggested at the conclusion of this paper.

With each successive dune, the height decreases coastwards, the length of the landform increases, alignment swings more towards facing the west and the proportion of sand to cobbles increases until the outer (cliffed) dune is composed almost entirely of sand with cobbles revealed only in trenches at 198309 and in pits dug along the line of the dune. The four remaining dunes of this system lie parallel to the fifth just described and are gentle swells abutting onto a stepped raised basalt shore platform at 15-25 feet northeast of 'Westella'. Their surface morphology is much disturbed by cultivation.

Within the built-up area of the town proper, between the Glenhaven shoreline and the Brigadoon shoreline is a maximum width of 600 yards. Between the Leven and 'Sunshine' the disposition of the Glenhaven shoreline fossil dunes is difficult to determine owing to human interference, but there appear to be five ridges west of Buttons Creek and three east of the creek, pivoting southeastwards from the raised basalt shore platform (30.88 feet) at 177314. The influence of Buttons Creek upon this flight of dunes can be seen in Figure 6 on which prior outfalls are marked. The composition of some of these dunes shows the possibility of Buttons Creek having once terminated in a barrier lagoon.

The age of the Ulverstone and Glenhaven shorelines

The Tertiary/Quaternary boundary is not ascertainable in the absence of datable deposits, but the dissection of the Lower Coastal Surface (Davies, 1959) appears to have been a Pleistocene event, initiated at least in part by changes in the level of the sea with respect to the land. The dissection involved the incision by streams to depths of several hundred feet below the level of the surface. (Figure 2). The present landscape may be described as one with gently rounded interfluves and V shaped valleys which for the most part are graded to the present sea level. Some sections of the valleys are alluviated and there are depositional terraces above the Leven which, in terms of height above the river, correspond to the Ulverstone and Glenhaven shorelines. This implies, but does not prove, that the rivers were earlier graded to these shorelines.

The work of Jennings (1959) on King Island has established a sequence of shorelines very comparable with those of this study area. He assigns those shorelines within the range of 20 to 65 feet above M.H.W. Springs to the Last Interglacial on the grounds of morphology and soil development and a comparison with coastal terraces in other parts of the world. The contrasts in morphology and soil development noted by him apply closely to the Ulverstone situation except for the absence in this study area of transgressive dunes. Gill and Banks (1956) provide Upper Pleistocene dates for deposits of comparable morphology and height in the Smithton area. In the absence of datable deposits from the Ulverstone area, if one accepts the interpretation of an Upper Pleistocene age for the Ulverstone strandlines within the range 20-65 feet above M.H.H.W., then the 110 feet shoreline may be older than Last Interglacial or may represent an early interstadial within the Last Interglacial. The former is much more likely.

Gill (1961 and 1964) and Ward and Jessup (1965) find shorelines at heights similar to those mentioned above in Victoria and South Australia, though there the picture is complicated by neotectonic activity. There are no known post-palaeozoic faults in the Ulverstone district west of the Don Heads (Burns, 1964). None of the shorelines at Ulverstone shows height variations other than those expectable in terms of variation in exposure to marine processes and subsequent erosion. In the absence of any positive evidence to the contrary, the Ulverstone coast is considered to have been tectonically stable with respect to east-west vertical movements. Movement normal to the coast cannot be discounted, but this is likely to have been downwarping towards the Bassian Depression rather than the repeated uplift indicated by the existence of raised lagoons, shore platforms and fossil dunes that repeat the alignment of the present coast. The sum of the evidence indicates that the old shorelines are Last Interglacial in age and older, and are due to Pleistocene glacio-eustatic changes in the level of the sea with respect to the land rather than due to tectonic changes in the level of the land with respect to the sea.

THE BRIGADOON SHORELINE

The mean of 32 measurements of the height of the base of the scarp falling from the Glenhaven terrace dunes at West Ulverstone is 3.23 feet, with a standard error of 0.09 feet. 18 measurements along the scarp base behind East Beach yield a mean of 3.93 feet with $SE_m = 0.06$ feet. The single reading of 4.50 feet for the back of the pebble beds at Lodders Point agrees with the mean of 13 measurements of the scarp foot between 'Sunshine' and 'Clayton', which is 4.53 feet, with $SE_m = 0.13$ feet. In terms of the standard Ulverstone datum, these values are between 3.23 and 4.53 feet above mean higher high water, and show an in-

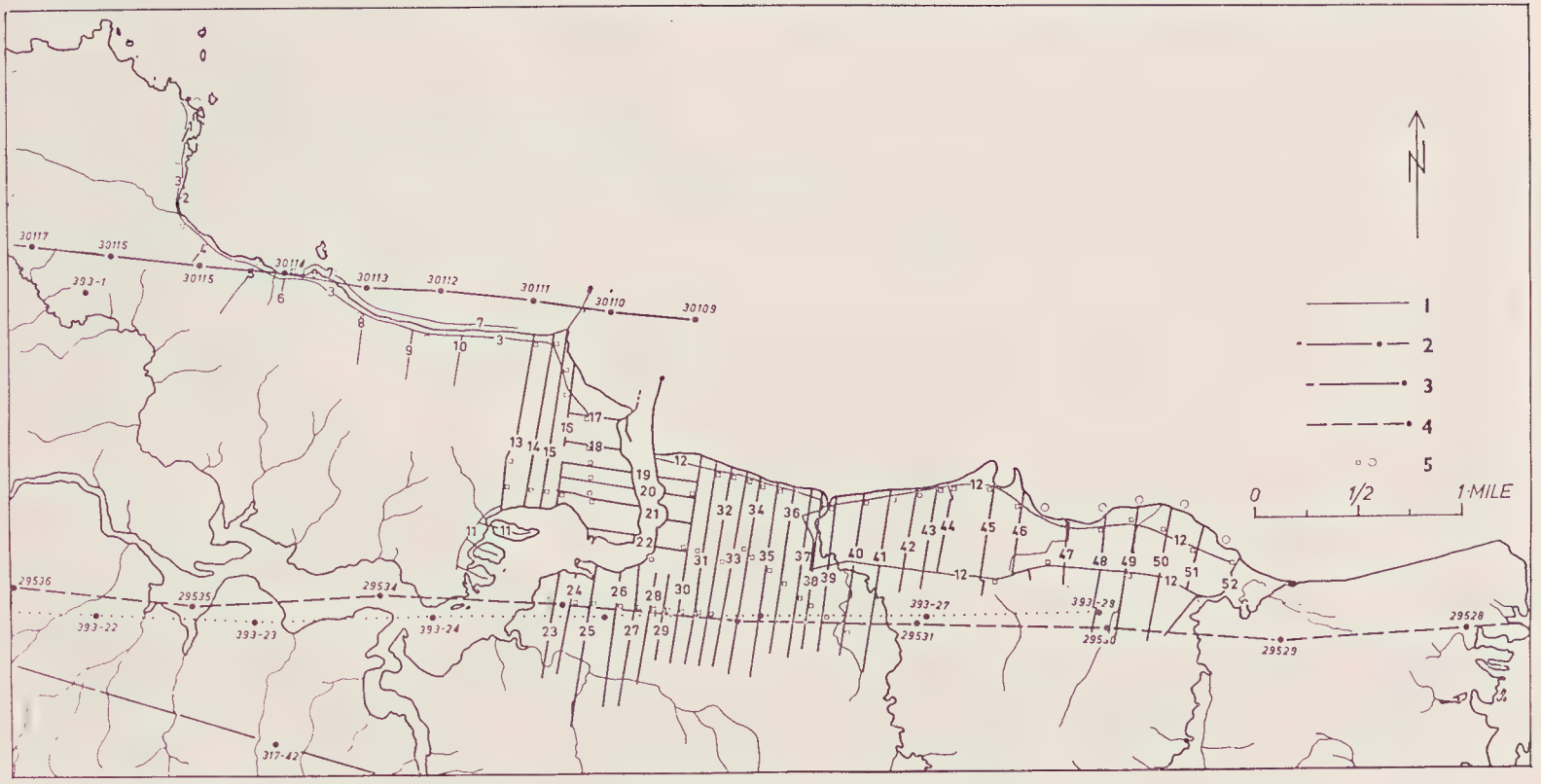

Fig. 3.—Ground survey lines and aerial photography.

1. Line of ground survey by level and theodolite.
2. Photo series of 1945: (6,750 feet) 20 chains to 1 inch.
3. Photo series of 1956: (20,000 feet) 40 chains to 1 inch.
4. Photo series of 1964: (7,500 feet) 20 chains to 1 inch.
5. Bench marks (Railways Department, State Permanent Marks, Ulverstone Municipality and temporary bench marks put in by the writer). Datum = State Datum. Circles show sample sites listed in the Table.

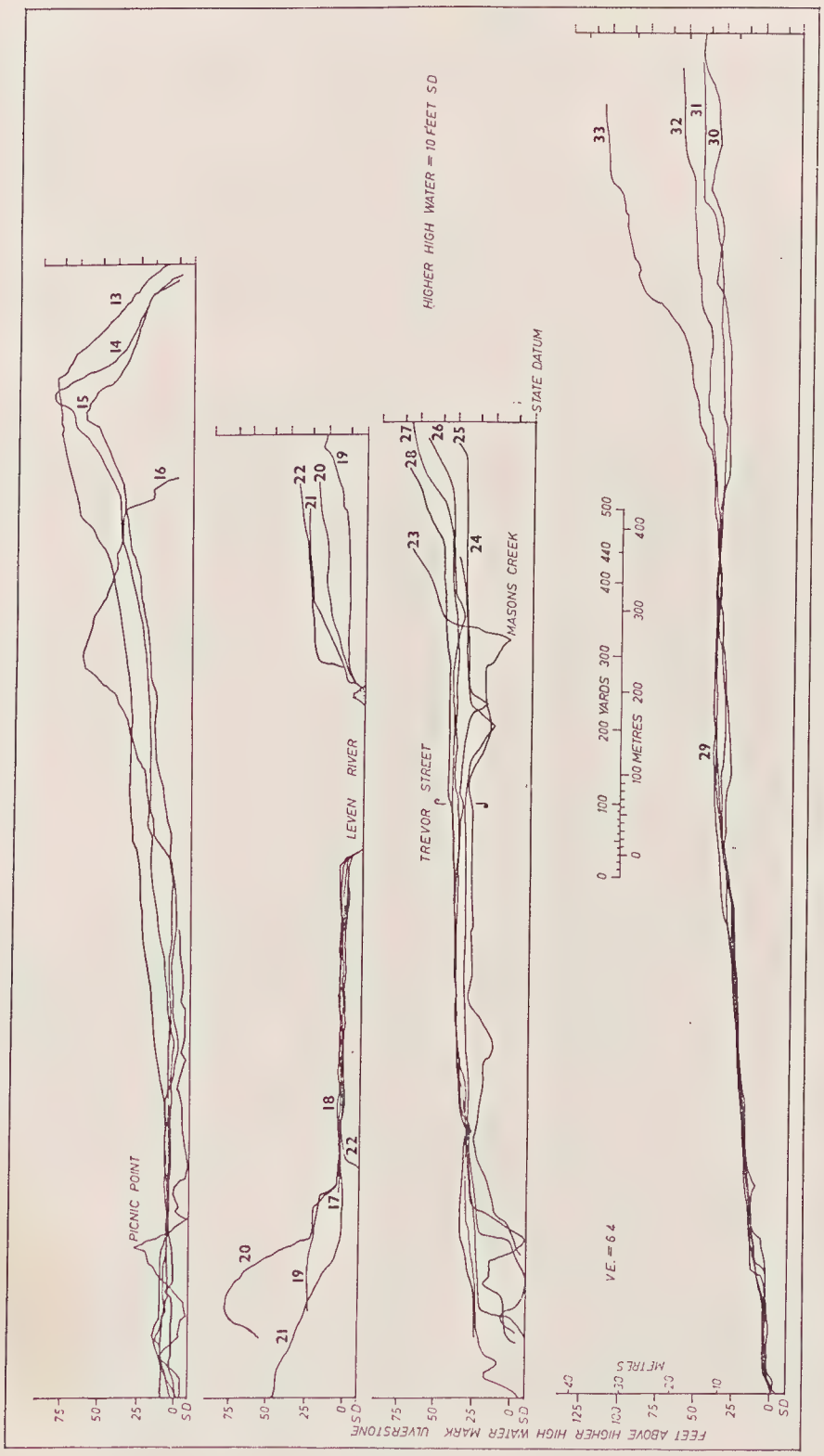

Fig. 4.—Survey traverses (see Figure 3 for location).

a. 13-16, West Ulverstone
b. 17-22, Leven River mouth
c. 23-28, aligned to Trevor Street
d. 29-33, centre of township

Heights are given in feet and metres above mean higher high water mark, and also in feet above State Datum.

crease of 1.3 feet from the sheltered parts of the coast between Picnic Point and the estuary and the more exposed environments. On taking these local variations in exposure into account, the Brigadoon shoreline can be considered to be about 3.25 feet above the present mean upper still water level.

At Lodders Point the sediments are being eroded at the back of the east facing storm beach, though the beach facing north appears to be either static or prograding. At the back of the main beach an auger hole was put down through the dune to the level of cobbles. The dune sediments were without any carbonate material even though the modern beach only a few feet lower was rather shelly. The material near 'Brigadoon' is also leached sand, boreholes having reached to —23 feet (14 feet below mean low water springs) in 1961, with sand all the way. The surface consists of a series of low ridges increasing in height towards West Beach. East of the Leven, the proportion of cobbles to sand increases until, east of 'Sunshine', post-Brigadoon deposition consists of a descending series of pebble ridges, though, at 194314, a sand dune behind a cobble beach which has no local source of sand is also carbonate free even though exhibiting scarcely any profile development. Dunes just behind the foredune at Picnic Point have a more developed soil profile.

The Brigadoon shoreline, at 3-5 feet above M.H.H.W.M. is regarded as Holocene in age and may mark the upper limit of the postglacial marine transgression. Davies (1959a and 1961) has identified a postglacial shoreline at 5-6 feet above H.W.M. along the North-West Coast of Tasmania which he correlated with a shoreline at 2-3 feet above H.W.M. in southeastern Tasmania. This is the Milford shoreline which he believed to relate to a postglacial higher sea level. The Brigadoon shoreline appears to be a correlate of the Milford shoreline. However, the present extreme upper limit of wave action at Lodders Point and on Alecto is 6 feet above M.H.H.W. Thus the status of the Brigadoon shoreline at Ulverstone as a raised shoreline in the sense of a fall in sea level since its formation is not unchallengeable. Davies (1961) claimed that Tasmanian beach ridge systems such as those at Ulverstone were built during a fall in sea level, but Hails (1965) is a critical review of eastern Australian (but not Tasmanian) evidence stated that much data, particularly that based on deposits, postulating postglacial higher sea levels, is equivocal. This appears true for Ulverstone.

Nowhere could the Brigadoon shoreline be seen to be strictly rock cut. On exposed parts of the coast between 'Sunshine' and 'Clayton' most of the Brigadoon shoreline is cut into post-Glenhaven shoreline dunes. Behind East Beach, raised lagoon deposits and dunes are cut back, while at 'Brigadoon' itself, the scarp is cut into Last Interglacial deposits with postglacial deposits at the scarp foot. The same is true east and west of Goat Island and at Lodders Point where the rock scarp foot is covered with cobbles. A large excavation would be needed to find the bedrock base.

Where the Brigadoon shoreline is highest above M.H.H.W.M., the shoreline is most exposed and there are wave-built ridges of cobbles and pebbles, materials which can be thrown above high water mark. (The windows of 'Clayton' have been shattered by storm-flung pebbles). At the more sheltered site at West Beach, the initial cutting of the scarp into the post-Glenhaven shoreline sediments is believed to have occurred prior to the establishment of the wave-built river-mouth bar.

The morphology of the post-Brigadoon shoreline deposits can be explained by initial rapid sedimentation followed by a gradual reduction in the rate of delivery of material to the coast, especially from offshore after a stable sea level had been reached. Differences in height between the Milford and Brigadoon shorelines are possibly a function of tidal range. It does not appear to be necessary to invoke sea level change to explain the morphology of the Brigadoon shoreline.

THE PROBLEM OF THE COBBLES

Cobble and pebble material is rare on Tasmanian beaches. Four possible origins may be suggested for it: it may be derived locally from rocks along the present coast; it may have been quarried from the sea floor or delivered to the coast by rivers and then redistributed by marine processes; or it may have been recycled following the erosion of prior marine terrace deposits.

Davies (1961 and 1965) suggested that the presence of cobbles and pebbles on the beaches associated with the mouths of the Forth and Mersey rivers is attributable to the function of these streams as glacial meltwater outlets in the late Pleistocene. The glacifluvial valley trains of these streams contain material of the same lithologies as are found as exotic pebbles on the Ulverstone coastline in pebble beaches and storm ridge systems between Lodders Point and Claytons Bay, and again eastwards to Pardoe Beach. The lithology of nine samples, each of over 300 beach pebbles, is given in the table below. Material not of immediately local origin is given in italics.

The cobbles found as raised storm ridges, capped by sand, associated with the Glenhaven shoreline, have already been mentioned. They too are not of local origin. The country rocks behind the site of the Glenhaven fossil dunes and ridges are Tertiary basalts above garnet schists and quartzites of the Precambrian Forth Metamorphics. The cobbles, however, include basal Ordovician greywackes and conglomerates, very variable Cambrian dacitic volcanics, gabbro, jasper and chert, and several types of Precambrian quartzites, none of which is found in the coastal bedrock nor in the catchment of Claytons Rivulet, but which do outcrop in the catchment of the Forth river. Cobbles of the same lithologies are also found across the Clayton on the old rifle range at 40 feet, and on parts of the higher terraces associated with the mouth of the Forth River. At shallow depth the sandy matrix is well cemented.

If one accepts a Last Interglacial age for the post-Glenhaven shoreline terrace sediments on the ground of comparability of altitude, morphology and soil development with those described by Gill and Banks (1956) and Jennings (1959), then the implication is that this material was delivered to the shore when the Forth was an outlet for glacial meltwater, and that it was redistributed when the sea level was at a height acknow-

Fig. 5.—Landforms west of the Leven River mouth.

1. Sand beach sediments
2. Cobble beach sediments
3. Salt marshes; sand and mud flats
4. Reefs and platforms on Palaeozoic rocks
5. Platforms on Tertiary basalt
6. Raised platforms on Palaeozoic rocks
7. Post-Brigadoon shoreline surface (sandy)
8. Post-Brigadoon shoreline surface (cobbly)
9. Post-Glenhaven shoreline surface
10. Post-Ulverstone shoreline surface
11. Higher marine bench (55-65 feet)
12. Higher marine bench (110 feet)
13. Lower Coastal Surface and scarps
    a. Modern shoreline
    b. Brigadoon shoreline
    c. Glenhaven shoreline
    d. Ulverstone shoreline
    e. 55 feet to 65 feet shoreline
    f. Scarp; landslips
    g. Beach ridges
    h. Dune
    i. Fossil dune

ledged to be, for tectonically underformed areas of Southeastern Australia and Tasmania, of Last Interglacial age. Paterson (1965) and Paterson, Duigan and Joplin (1967) have suggested two glacial phases for the Forth River system on stratigraphic, petrological and palynological evidence from Lemonthyme Creek. Although categorical proof of this claim cannot be made from this coastal geomorphology, or even perhaps from a stratigraphy and palaeontology of the coastal deposits, the distribution and disposition of the cobbles do suggest two lines of thought. First that the raised cobble deposits are glacifluvial outwash from an earlier glacial phase, deposited in part as river mouth terraces and in part as storm ridges, and secondly that the cobbles of the modern shoreline are probably mostly marine redistributed glacifluvial material of the last glaciation. An unknown proportion of the postglacial deposits is thought to have been recycled from the raised deposits as evidenced by the incision of the Forth into its old river mouth terraces and the cliffing of the Glenhaven terrace deposits during the formation of the Brigadoon shoreline.

TABLE: PEBBLE LITHOLOGY (PERCENT)

	SAMPLE SITES								
	Lodders Point	¼ mile west of Goat Island	220 yards west of Goat Island	220 yards east of Goat Island	Coast, north of 'Westella'	500 yards east of 'Westella'	Midway between 'Sunshine' & 'Clayton'	700 yards west of 'Clayton'	Coast, north of 'Glenhaven'
PRECAMBRIAN									
Ulverstone Conglomerate		0.8	0.6	42.1					
Quartzite	*19.1*	22.7	3.6		*70.2*	*57.5*	*36.3*	*14.9*	*17.9*
Rocky Cape Sandstone			8.4	50.0					
Garnet schist						0.6			6.0
Phyllite		0.8							
Purple Quartzite					*2.0*				
Aventurine					*0.5*				
CAMBRIAN									
Chert	47.5	9.2	18.0	*3.7*	*2.9*		*0.7*		
Chert breccia	5.7					*0.6*			
Greywacke		5.8							
Mudstone	14.9								
Spilite	8.5	2.5							
Dacite					*7.8*	*4.0*		*1.5*	*2.4*
Jasper	0.7						*0.7*		
Vein Quartz	0.7	0.8	3.6		*2.9*		*0.7*		
ORDOVICIAN									
Basal greywacke and conglomerate	*1.4*		*1.8*	*1.1*	*3.9*	*2.9*	*3.0*	*4.1*	*4.4*
TERTIARY									
Limonite	1.4		1.2						
Basalt		2.5	62.9	3.2	9.3	34.5	57.8	78.5	71.4
Amygdaloidal basalt		54.6			0.5	0.6		1.7	

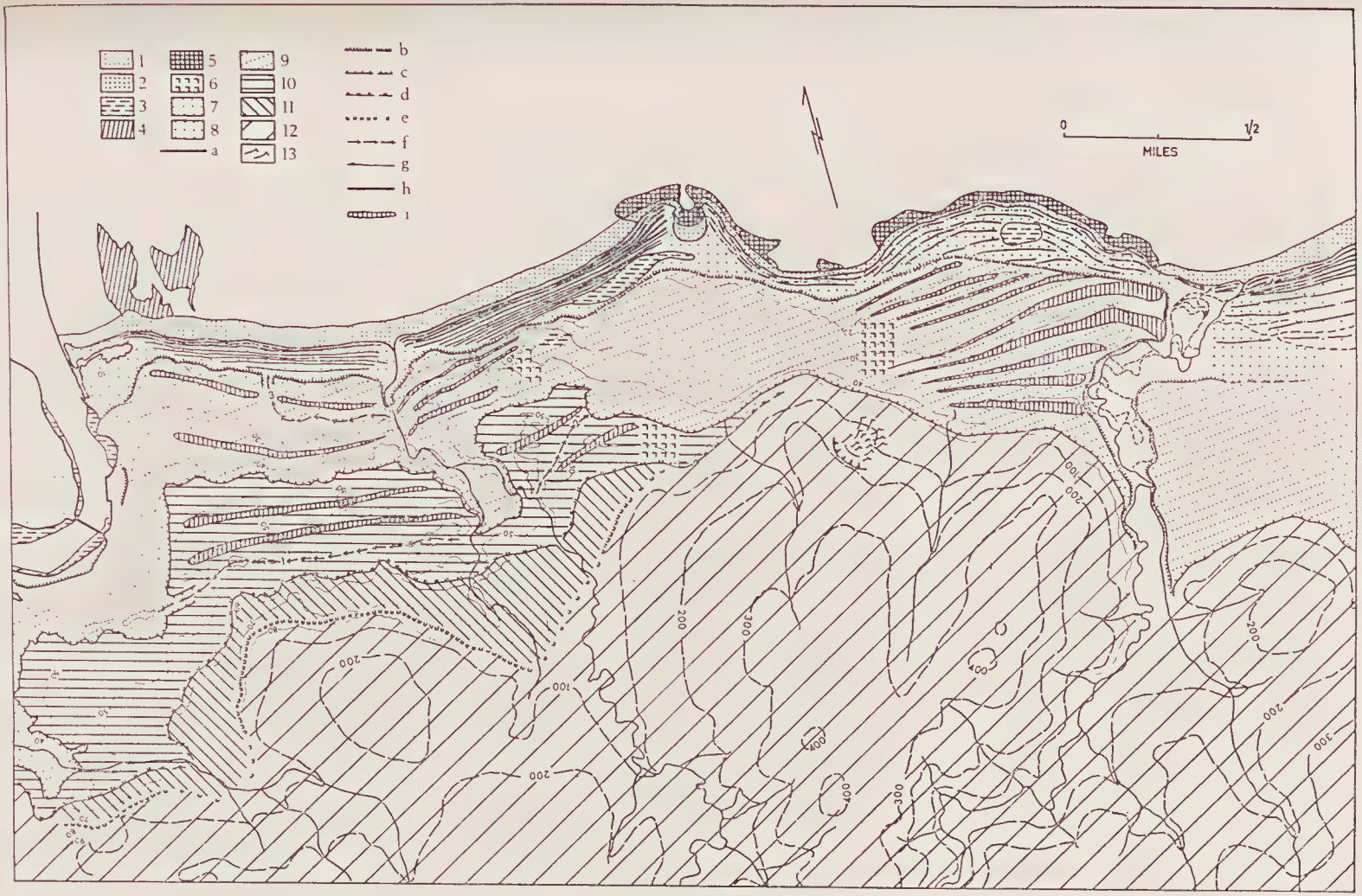

Fig. 6.—Landforms east of the Leven River mouth.

1. Sand beach sediments
2. Cobble beach sediments
3. Sand and mud flats, swampy.
4. Reefs and platforms on Palaeozoic rocks
5. Platforms on Tertiary basalt
6. Raised platforms on Tertiary basalt
7. Post-Brigadoon shoreline surface (sandy)
8. Post-Brigadoon shoreline surface (cobbly)
9. Post-Glenhaven shoreline surface
10. Post-Ulverstone shoreline surface
11. Higher marine bench (55 feet to 65 feet)
12. Lower Coastal Surface and scarps
13. Landslips
    a. Modern shoreline

b. Brigadoon shoreline
c. Glenhaven shoreline
d. Ulverstone shoreline
e. 55 feet to 65 feet shoreline
f. Prior stream courses
g. Beach ridges
h. Dune
i. Fossil dune

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I wish to express my gratitude to the many people without whose help and co-operation this study would never have materialized. Special thanks are due to Dr J. L. Davies, Reader in Geography, who provided financial security in the form of a part-time research assistantship, and gave so much helpful advice and criticism. There were many fruitful discussions with Mr A. Goede, Lecturer in Geography and Mr G. van de Geer, the department's cartographer. Mr M. R. Banks, Reader in Geology and Dr J. A. Beattie, Senior Lecturer in Soil Science excited the writers' interest in sedimentology and pedology respectively. I am very grateful to many friends in the Ulverstone district, particularly my uncle and aunt, Mr and Mrs T. K. Wilson of 'Clayton', and also my students: John Hensby, John French, John Eaton and Graeme Marshall, who gave happy and tireless help in the field.

REFERENCES

BURNS, K. L., 1964: Devonport Map Sheet. Geological Survey, Tas. Explanatory Report One Mile Series K/55-6-29.

DAVIES, J. L., 1959: High level erosion surfaces and landscape development in Tasmania. *Austr. Geogr.* **7,** 193-203.

————, 1959a: Sea-level change and shore line development in south-eastern Tasmania. *Pap. Proc. Roy. Soc. Tas.* **93,** 89-95.

————, 1961: Tasmanian beach ridge systems in relation to sea-level change. *Pap. Proc. Roy. Soc. Tas.* **95,** 35-40.

————, 1965: Landforms (in) *Atlas of Tasmania,* 19-22.

————, (personal communication, 1965): *Preliminary report on sediment movement near the Mersey River entrance.* Unpublished ms. 27 pp.

EDWARDS, A. B., 1941: The North-West Coast of Tasmania. *Proc. Roy Soc. Vic.* **53,** 233-67.

FISH, G. J. and YAXLEY, M. L., 1966: *Behind the Scenery—The geological background to Tasmanian landforms.* (Education Department, Hobart).

GILL, E. D., 1961: Changes in the level of the sea relative to the land in Australia during the Quaternary era. *Zeitschr. für Geomorph. N.F. Sup.,* **3,** 73-9.

————, 1964: Quaternary shorelines in Australia. *Aust. J. Sci.* **26,** 388-91.

GILL, E. D. and BANKS, M. R., 1956: Cainozoic history of Mowbray Swamp and other areas of North-West Tasmania. *Rec. Queen Victoria Mus. Launceston. N.S.* **6,** 1-42.

HAILS, J. R., 1965: A critical review of sea-level changes in Eastern Australia since the Last Glacial. *Austr. Geogr. Stud.* **3,** 63-78.

JENNINGS, J. N., 1959: The coastal geomorphology of King Island, Bass Strait, in relation to changes in the relative level of land and sea. *Rec. Queen Victoria Mus. Launceston, N.S.* **11.**

NORTHCOTE, K. H., 1965: A factual key for the recognition of Australian soils. (2nd. Ed.) *C.S.I.R.O. Div. Soils Rep.* 2/**65.**

PATERSON, S. J., 1965: Pleistocene drift in the Mersey and Forth valleys—Probability of two glacial stages. *Pap. Proc. Roy. Soc. Tas.* **99,** 115-24.

PATERSON, S. J., DUIGAN, S. L., and JOPLIN, G. A., 1967: Notes on Pleistocene Deposits at Lemonthyme Creek in the Forth Valley. *Pap. Proc. Roy. Soc. Tas.* **101,** 221-6.

WARD, W. G., and JESSUP, R. W., 1965: Changes in sea-level in Southern Australia. *Nature.* **205,** 791-2.

[*Manuscript received 21st September, 1970*

A SURVEY OF THE MSS, LOGS AND SHIPS JOURNALS IN THE STATE LIBRARY OF TASMANIA

PART I.

THOSE IN THE ARCHIVES DEPARTMENT OF THE LIBRARY WITH EMPHASIS ON THE LOGS CONCERNING THE WHALING INDUSTRY

'BILL THE WHALER'

'You must have been a whaler
That's clear as clear can be,
For you walk like one
You talk like one
Said Whaler Bill to me.
'And you think like one
And you drink like one
You must have been to sea.'

WILL LAWSON

By permission
from 'Bulletin' of 6-10-1943.

By

W. E. L. H. Crowther, F.R.A.C.P.

Hon. Adviser in Australian Bibliography, State Library of Tasmania.

SURVEY

INTRODUCTION

This Survey from the State Library of Tasmania has been compiled from the series of Logs deposited in 1960 in the State Archives by the Ship Lovers Society of Tasmania. Other voyages included were the Logs of the schooner *Eliza* (William Walker Collection), the *North American* and *Australasian Packet* from the Van Diemen's Land Museum, and a Log containing two voyages of the *Menkar* (from the Crowther collection).

An alphabetical list of the voyages similar in form to that employed by S. C. Sherman in 1965 (Sherman, S. C.): 'The Voice of the Whaleman' has been employed (see Infra). In addition detailed typed abstracts of each voyage in an individual manilla folder have been added as an appendix, thus providing an additional source of reference.

It is the intention of the writer to follow this appendix with a second (Part II) concerned with the Logs in his own Collection and housed at the State Library. With its completion it is expected that tentative conclusions may be put forward as to the methods and manner in which the whaling industry of Tasmania and perhaps other Australasian centres was conducted during the middle and later decades of last century; which witnessed the flowering and termination of the taking of the Sperm whale by ships large and small on the high seas in areas by which they emigrated to warmer seas where their food the giant squid might be found. Again from these first hand accounts one may appraise the aptitude and qualities of the Master and their crews of the local ships, as compared to those of their mentors and rivals on the famous whale ships of the enormous fleets from the New England ports of the United States.

FOREWORD

Here are some factors that directed me to this task.

It was inevitable that from early childhood one became interested in whaling.

Hobart at that time had a large fleet of ships of her own trading to the Colonies of Australia and New Zealand and to the United Kingdom and other overseas countries, and there was always something of interest to see or to read in the shipping news of the press.

A much loved uncle Henry L. Crowther, Stipendiary Magistrate at the Huon came to Hobart each month to take his court at Kingston, arriving from Franklin by coach and staying with my father until his return on Monday morning.

It was his custom on Sunday afternoon to walk part of our large family of six children. He always followed the same course by Murray Street to the long stretch of the New Wharf, from the ferry and Watermans slipway (where they drew up their boats waiting for a hire), to the Princes steps by Castray Esplanade.

This area was sacred to the sailing ships, the steamers went to the other side of the harbour.

At the town end of the Princes Wharf were the London and overseas traders, large barques or full rigged ships taking on whale oil and wool. Further along the smaller barques and brigs took the intercolonial trade, Mauritius for sugar, pineapples and bananas from Queensland etc., etc. Last in the row were the whalers, only two of them at this time (c1895) the *Helen* and the *Waterwitch*. The wharf opposite where they were berthed reeked of whale oil which seeped from the long rows of barrels of whale oil lying on their sides on the wooden timbers.

Arriving home in due course, our father would ask what we had seen, and he would then tell us of *his* father's ships. My grandfather (1817-1885), a surgeon by profession and speculator by nature had three such interests. Timber mills at Castle Forbes Bay and later at the 'Tiers' behind Kettering, D'Entrecasteaux Channel, whaleships and the Guano trade. His ships included the ship *Offley* barques *Isabella, Sapphire, Juno,* the brig *Velocity*' and the schooners *Elizabeth Jane* and *Flying Squirrel* and *Marie Louise.* My father told us of the best remembered masters, namely Capt J. W. Robinson, A. B. Robinson and Copping, with others Captain Saunders and Abbott, also concerning the crews of these ships and their adventures and exploits.

Later my marriage in 1915 to the Great granddaughter of Charles Seal the outstanding whaleship owner of the Thirties and Forties of last century also extended my interests.

Entering private practice at Hobart gave one as patients Capts A. B. Robinson, Scannen and W. McKillop, the latter an outstanding seaman and of literary mind. His memoirs were used by Will Lawson in his last two whaling books and that delightful series of ballads concerning 'Bill the Whaler' which first appeared in the Bulletin (1943).

Harry Power a boatman at Bellerive also my patient had served with Paddy Gilroy in the *Chance* on the occasion described by Frank Bullen in the 'Cruise of the Cachelot (infra) when in a hard gale and on a lee shore—Paddy with his mixed crew of whalers largely Maori in composition, snatched a whale almost from the breakers on the lee shore of the Solanders, to the admiration and envy of the more orthodox crew of the *Cachelot.*

So much for the personal factors.
(See note end of this section).

The Nicholson Collection of whaling material at Providence Library, Rhode Island is concerned almost entirely with MSS, Logs, Ships Journals and whaling account books, comprising a total approaching the 1,000 mark.

Inquiry of all the principal Libraries in Australasia and New Zealand reveal the paucity of their holdings in such material.

The Mitchell with a score of 300 (no details then given) is overwhelmingly superior to all the others. Next in members is the State Library of Tasmania with 34 Logs (including 8 of whalers), my own Collection housed in the State Library is numerically larger and therefore the total holdings of State Library will be a very important source of reference for research in the industry.

Apart from whaling, each variety of log has its very real and personal interest viz. the personalities and difficulties and risks of the crew in the small ships of the timber trade, taking hardwood to New Zealand and the outposts of W.A., S.A., N.S.W. and Queensland and returning, inter alia, with softwoods to Hobart Town, Tasmania.

Again the introduction by Straubels 1854 in Capt Rhodes whaling Journal gives a valuable and interesting description of the Sydney whaling trade not available readily elsewhere.

To help in the summary of voyages that follows, it must be remembered that while the Americans would give their catch as say S.O. (Sperm oil) of 1200 barrels, B.O. (Black oil) 1500 barrels and whalebone 200 lbs a Colonial extract might read 'From the South Seas' 25 tons. A Tun or Ton was apparently equal to eight barrels again equal to 252 gallons.

Note: William McKillop in his eighties sailed as a guest on a 38 ft cruiser the *Conella* of which I was part owner. We persuaded him to write his whaling memoirs. These a patient of mine, Mr McLoughlin transcribed into his own legible script, and the original in Capt McKillop's handwriting went I think to Capt O'May. Will Lawson drew largely on McKillop's writing in his *Blue Gum Clippers, Harpoons A'Hoy and Bill the Whaler.* I had a deep affection for Capt McKillop, he was a highly cultured Scot born in the Southland, N.Z.

Will Lawson's description of his *Bill the Whaler* dedicated to him, does not indicate the great gentleman that McKillop was.

Another old friend was Capt Cook, who wrote occasional whaling articles to the Auckland *Herald* under the cognomen of *Lone Hander.* One concerned the *Sapphire* my grandfather's barque on which McKillop had served (as mate or 2nd mate). He had been born at Steward Island, his people having gone there from Sydney in the earliest era of Colonial settlement in Australasia.

A visit to Auckland in 1937 enabled me to meet Capt Cook and his family as he was ending his days at Parnell in that city.

Both McKillop and Cook were slightly built spare men medium to tall, reticent and slow in speech and gentle in manner, far removed indeed from the popular conception of a mate of a whaleship but both outstanding mates of southern whalers.

SHIPS AND JOURNALS

STATE LIBRARY OF TASMANIA

ANNIE

Barquentine 201 tons. Accession No. 17.

Joseph Ikin, Master, owners A. Aust. Guano Co. Engaged in Guano trade between Bird and Lady Elliott Islands (Coral Sea Q.) and Launceston May 1882-16th July 1882. Driven on shore became a complete loss at Bird Island on latter date. The lives of all on the ship were saved.

AUGUSTUS

Barque 400 tons. Accession No. 6.

Master and part owner William Young; Burn, White & Co., Agents.

On a whaling voyage, principally in Tasmanian waters. 5th April-22nd Sept. 1850.

AUSTRALIAN PACKET

Barque 205 tons. Accession No. 4.

William Chamberlain Master 'On a voyage to Southern Waters' from Hobart Town 6.2.1860-20.2.1861. Log kept by James Chamberlain, Chief Officer, 6th April 1860-20th Feb. 1861.

S.W. coast of New Zealand-Researche Bay-Cape Sorell. Sperm whales seen with no success on lowering —Port Davey-Researche Bay, searching without success—middle grounds towards Lord Howe and Norfolk Islands. Several whales taken.

Arrived Hobart Town, 20th Feb. 1861. Press report 'from whaling with Sperm oil' (but does not indicate the actual amount taken). A monotonous voyage until last stages, uneventful for members. Local and American ships sighted and spoken. See infra for two other whaling voyages of this ship. Certain of the pages at the end of the log contain valuable data as to the addresses etc. of the crews of the ships commanded by Captain Chamberlain in the early sixties of last century.

CARTELA

Steamship. Owners, Huon, Channel and Peninsula S.S. *Coy.* Chartered to carry fruit from D'Entrecasteaux Channel to Melbourne during the great shipping strike. P. Johnston, Master, 6th July-12th Aug. 1919. The vessel was not designed for outside work and strained her timbers and leaked badly, proceeding by short dashes from bay to bay and island to island. Ran out of coal and waited at Wilson's Promentory for coal to be sent to her as she sheltered there. The voyage back was less dangerous and she made Barnes Bay safely where she was quarantined owing to the Pan-Influenza outbreak.

CORINNA

Steamship 820 tons. *Accession No. 18.*

R. Soden, Master, on a delivery voyage from the makers at Glasgow for the Tasmanian Steam Navigation Co. at Hobart Town, 19th May-22nd July 1892.

Engine room log only kept by Parlan McFarlane, Chief Engineer.

Passed Cape of Good Hope on 42nd day. Average cruising speed on passage nine knots, and coal consumed per diem 2½ tons. Taken into the Launceston-Sydney run under Capt Drysdale.

EMILY DOWNING

Barque 269 tons. *Accession No. 9.*

J. J. Cannon, Master, 29th Nov. 1883-17th Jan. 1885.

Kept by J. Cooper, Mate.

To Middle Grounds and New Zealand sperm whaling, no noteworthy incidents.

This barque was built at Port Arthur as the *Lady Franklin* in 1845. Sold out of Government service to F. H. Downing, Merchant, renamed after his daughter and fitted as a whaler. Later under the McGregor flag and in 1885 purchased by the Imperial Government to serve as a powder hulk. Eventually burned out lying at Domain slipyards.

EMU

Barque 381 tons. *Accession No. 3.*

Only a fragment of the Log dealing with last phase from Cape Town to Van Diemen's Land, 1st Dec.-30th Dec., 1841. Called at V.D.L. Coy's establishment at Circular Head en route to Hobart Town. Landed at Circular Head, passengers and supplies. For further record of this ship see Ref. Crowther 1931 M.J. of Australia.

ESK

Steamship Accession No. 13.

Captain Langford—Trading between Tasmania, Victoria and New South Wales and occasionally to outports for the Tasmanian Steam Navigation Co. Compiled in succession by A. Drysdale and C. P. Sharpe, 14th Jan. to 7th June 1882.

HARRIETT NATHAN

Barque 186 tons *Accession No. 5.*

Alan Christy, Master, Two Intercolonial voyages trading to Port Phillip and coal mine at Schouten Island, 19th Nov. 1849-6th Jan. 1850 and 27th Nov. 1850-17th Dec. 1850.

Launched from Williamson's slipyards Hobart Town 19th Nov. 1844 for Nathan, Moses & Co. Later used as a whaler. Lost about 1867 in Tasman Sea on a voyage towards New Zealand.

HEREFORDSHIRE

H.E. India Co. *Accession No. 11.*

Capt I. C. Whitman — A manuscript Log of the voyage London-Bengal. Malacia and Whampoa (China) and return via Cape Horn and St Helens.

Trading and transporting of small military detachments 21st Jan. 1827-16th March 1828.

Kept by Alfred Kennerley (Midshipman on the Hon. E.I. Company Service), who later returning to Australia, became the Hon. A. Kennerley in 1873, Premier of Tasmania.

The rear pages of this Journal have records by A. K. of incidents of subsequent voyages made by him between England and Australia (Infra).

JUPITER Ship (Under 'Herefordshire')

Captain Waldy, Master on a voyage Plymouth to Sydney 17th Aug. 1828-21st Mar. 1929. Alfred Kennerley a passenger, long and vague entries describing his personal reactions.

SURREY Ship (Under 'Herefordshire')

Captain Dacres, Master, Sydney-New Zealand and return voyage via Launceston V.D.L. 9th April 1829-19th March 1830. Compiled by Alfred Kennerley, no detail given.

VIBILIA Ship or barque (Under 'Herefordshire')

Captain Stevenson, Master. London-Sydney via Hobart Town 4th April-Oct. 1831. Odd mention of events and dates.

KATHERINE STEWART FORBES (Under 'Herefordshire')

27th May-27th Sept. 1830. Voyage from Sydney to London, via Bahai, Bengal, a mere record of A.K. having made this voyage.

JULIE

Brig. 135 tons. Master Captain Dart. On a whaling voyage from Hobart Town 7th Feb-23rd Aug. 1837—Port Davey and coasts of V.D. Land.

LASS OF GAWLER

Barque *Accession No. 21.*

J. James, Master, in cargo trade Intercolonial. 9th Jan. 1884-22nd March 1885. Various cargoes, mainly timber. Port Adelaide-Gages Rds (W.A.).

Quandeloup (W.A.) Port Victor S.A. Northern Rivers, N.S.W. and Hobart Town. Log terminates with ship sold at auction at Hobart Town to Huddart Parker & Co. Hulked for coal purposes and remained in this capacity until broken up in recent years.

MACCLESFIELD

Ship *Accession No. 1.*

John Moore, Master. Voyage from Cork, U.K. to Hobart Town 1822.

A brief record of facts on board, in a note book, kept by Peter Harrison an emigrant who founded his family in V.D. Land. Contains a list of passengers, dates and names of those on board, and such occasions as when at the commencement and end of the voyage the ship was ashore and refloated without damage. An exceptionally long voyage, exciting alarm at Hobart Town by the non appearance of the ship.

MARY WADLEY

Accession No. 23.

Master J. W. Whitton, owners Forn & Harris—Timber merchants of Hobart.

A voyage from Woolgoolga (Q.) towards Hobart 20th Dec. 1892-3rd Dec. 1893. Incidents of a most hazardous voyage in a series of gales. The ship was finally driven ashore at Garden Island Creek, Huon, April 1901. Total loss but crew saved.

MYSTERY

Schooner P. Owens, Master.

On a trading voyage between Hobart and Launceston, July 1849-6th Jan. 1850. Lost on Swan Island 2nd March 1850.

NEMESIS

Steamship Accession No. 22

Owners Huddart Parker & Co.

Trading voyages principally between Hobart and Sydney 28th March-19th April 1899. Masters Captains Featherstone & Bentley—lost at sea with all hands off coast of New South Wales, carrying Newcastle coal 10th July 1904.

PRINCE OF DENMARK

Brig. 69 tons. *Accession No. 9.*

R. Heay, Master—'On a whaling voyage to the South Seas.' 8/10/1851-26/3/1852. Various areas of East Coast of New Zealand visited. Two whales taken off Hawkes Bay. Damaged in heavy weather.

The earlier voyages of this historic Brig. then in James Kelly's fleet, Bay whaling in V.D.L. and towards Portland and to the navigator Islands (Samoa) for pork, (will be found Infra Part II, Crowther Collection). See Ref. W. P. Bowden.

PRINCE REGENT (1)

Barque 287 tons *Accession No. 7.*

Master Captain Gardiner, owner Charles Seal, on a whaling voyage to Bering's Strait 7th Nov. 1849-3rd Nov 1850. Journal kept by F. G. Thompson. *An instructive and valuable record* in regard to the various areas visited in the Sub-Arctic areas of N. Pacific whaling and the number of whales taken and ships sighted. Not an official Log book.

PRINCE REGENT (2)

Accession No. 7.

Capt Gardiner-Charles Seal owner.

A second voyage to Berings Straits 20th Feb. 1851-December 1851. To Berings Straits via Fiji Islands and spoke the H.T. whaler *Wallaby* in that area, the only incident of note, until on 11th May passed through the Aleutian group of Islands and may be said to have arrived at the whaling grounds. 14th May lowered for Right whales all four boats without success. *16th May,* 3rd mate made fast at 10 p.m.

Next day cut in the whale and tried out. Spoke the 'Litherland' of Hobart Town. Charles Seal with 300 barrels of B.O. and 130 barrels of Sperm. *21st May* in drift ice.

23rd May, 2nd Mate got a whale and cut it in (last entry).

Here the *record ceases* abruptly. The ship arrived back at Hobart Town in Dec. 1851.

The Press merely reports her arrival and no mention of the reason for terminating the voyage. The Captain's wife was on board. ? what factors caused this premature return ? ice conditions ? factors concerning Mrs Gardiner or the crew. No hint is to be found.

RIO

Barquentine, 120 tons *Accession No. 25.*

Voyage (1) Capt. D. C. Johnston, trading from Mercury Bay, New Zealand-Sydney, Clarence River, Grafton, Newcastle and Rockhampton, timber trade 8th Feb. 1910-12th Nov. 1910.

RIO (Voyage 2). Accession No. 27.

Capts W. & E. Taylor (no indication of date of change of command) kept by *William McKillop* mate, covers three intercolonial voyages.

Hobart—Northern rivers and Queensland. 26th March 1914-13th July 1914. 14th July 1914-17th Sept. 1914.

Mostly in timber trade. *Lost at sea off King Island about the latter date.*

STRATHMORE

Schooner 110 tons. *Accession No. 24.*

G. Bennett, Master.

Trading with timber from Hobart—Alligator Creek, Queensland, Clarence River and various parts of N. and South Islands of New Zealand. Also taking timber from various out ports on the Tasmanian coast, one such place as Mussleroe River, N.E. Tasmania. Record kept by Edwin Knight and G. Griffiths, Master.

Driven ashore and lost, 12th June 1895. At Mussleroe Bay without loss of life.

SWORDFISH

Brigantine 111 tons. *Accession No. 15.*

J. H. Hurburgh, Master between Hobart, New Zealand and Adelaide-Newcastle, 3rd Aug. 1881-26th April 1882.

Wrecked near Flinders Island, kept by James A. Roper, Mate.

TERROR

Barque, 180 tons. *Accession No. 8.*

Master Captain Griffiths, owner Thomas Brown.

On a *whaling voyage* to S. Indian Ocean, 7th Feb.-27th Dec. 1851.

Hobart Town-East Coast of Tasmania-Researche Bay-Western grounds-King George's Sound. Bay whaling in Researche Archipelago without success. S. Indian Ocean to Port Davey and vicinity with some small success.

Colonial Times, 31st Dec. 1851 barque *Terror* Captain Griffiths from South Seas 40 tons Sperm Oil, not an inconsiderable amount for the length of time and area searched.

ZEPHYR

Schooner 90 tons.

W. T. Careless Master. In Colonial (timber trade).

Owner R. Sherwin. 30th Nov. 1876-6th Nov. 1877.

Hobart Town-Victoria-New Zealand ports and return to Hobart Town. *Cast ashore without loss of life when taking in Huon Pine logs at Port Davey in October 1877.*

CROWTHER COLLECTION

Menkar Ship 371 tons.

Voyage 18th Aug. 1851-6th April 1854. New London (U.S.A.) Flores—Falkland Island, Mocha Island. Samuel Juan Fernandes Is. Payta (Peru) Marquesus Is. Owymee, Sandwich Is. *Sea of Otkost, Berings Strait,* Diomede Is. 2nd Sept. 1852 last entry of voyage returned New Bedford 6th April 1854.

MENKAR

Ship 371 tons.

Owned U.S.H. A second voyage in same volume from New Bedford (9.5.1854) 'for North Pacific Ocean with a crew of 29 men' Flores-Martinvas Rocks-Inaccessible Island-Tristan D'Acunah-St Paul's, Cape Leuwin W.A. Poverty Bay, New Zealand, stranded on reef, *log ends ashore there on 29th Jan 1855.* N.B. gap of two years *in Log. Arrived at Hobart Town in March 1858* when ship was condemned as unseaworthy—her oil shipped to London for sale and the vessel and her fittings sold by auction. Purchased by a ship builder at the 'Franklins' (sic) and after repairs and a refit renamed the *Juno* and under this name joined the whaleships of the writer's grandfather and also shipped Guano from his establishment at Bird Island and Lady Elliott Island in the coral Sea west of N. Queensland.

VAN DIEMEN'S LAND FOLK MEMORIAL MUSEUM

AUSTRALASIAN PACKET

Ship Lovers Society on loan V.D.L. Museum.

William Chamberlain Jun. Master. 4th Feb. 1859-29th Feb. 1860.

From Hobart Town on a whaling voyage. On 3rd Feb 1859 Mr Evans joined the ship as Chief Officer and probably compiled this Log, 4 days later the Capt. joined the ship in D'Entrecasteaux Channel and sea Log commences. Thompsons Sound, New Zealand, Milford Sound, Mutiny of part of crew, sixteen left on shore. Whaling off S.E. Coast of New Zealand, Bligh's Sound. Heavy seas on passage towards Tasmania. Spring Bay for repairs, Kangaroo Island so towards King George Sound.

Whaling in that area. Return to area of Kangaroo Island and into Bight, Point Hibbs-Port Davey—more trouble with crew, 2nd mate leaves ship. *Grecian arrives and news of loss of one of his boats and its crew.* Whaling S. Tasman Sea with moderate success. Sickness on board, arrive Spring Bay with 2 men logged as having scurvy. 29th Feb. 1860 log terminates.

7th March 1860 reported at mouth of Derwent, winds too light, towed. A report in H.H.M. of 7th March 1860 states 24 tons of Sperm oil. *No mention is made of the scurvy or indeed any details of the cruise* in the local press at time of her arrival.

NORTH AMERICA Voyage A.

368 tons. Captain Pendleton, with a crew of 29 men on a whaling cruise to the *North Pacific Ocean 20th June 1849-26th March 1851, 2700 galls oil, 2800 lbs of whale bone*—New London, Fayal-Goughs Island, Banks Peninsula, New Zealand, Guam, Hervoey(sic) Is. Correa(sic) Straits-Sea of Japan Ochotisk-Berings Straits, St Lawrence Bay, Is. of Maree ? - Whao(sic) Log entries cease voyage ended, New Bedford 26/3/1851.

NORTH AMERICA Voyage B.

368 tons. Starbuck Vol. II page 466.

Mason, Master, Williams & Hines, Agents.

Indian & Pacific Oceans 3rd June 1852-20th April 1853.

In 1859 under Capt. Shepnell this vessel put into Hobart Town for repairs before proceeding to Berings Strait for whaling, she had only poor results there so returned to whale off coast of New Zealand taking a large Sperm whale which returned 80 barrels Sperm oil. The larboard boat lowered and Shepnell struck another, the boat was stove in and one of the crew had a leg broken. In the heavy gale the whale although got alongside was lost. The same gale gravely damaged the deck fittings and bulwarks and two boats were lost as well as other damage. The ship reached Hobart in 1861 was offered for sale, but built in 1810, did not attract a buyer. Later the McGregor Bros purchased her and employed her both as a trader and whaleship as the *Derwent Hunter*. For many years as a hulk she served as a shore ship and repair depot at the Domain slipyards. In 1907 she became alight and was burned to the waters edge. Is remembered as a successful whaler out of Hobart Town.

TERROR

Barque 180 tons (Shiplovers Society at V.D.L. Folk Museum).

Capt McGrath on a whaling voyage from Hobart Town 26th Oct 1848-9th Sept 1849. Compiled by Marney, Chief Mate, Researche Bay-Port Davey (7 other Hobart Town whalers in company). Cruising off shore 3 other ships in company (Dec. 18) each with a whale alongside. Saw a *Right* whale, lowered without success. Passed to Middle Grounds, Lord Howe Island 1st Feb. 1849—March refitting in Sydney. Ship struck ground hard off the pig styes. Cruising between Researche Bay and Port Davey 17th Aug. *Saw 3 Black whales* (? does this mean the S. Right whale). Took a Sperm whale on 28th—bearing up for Port Davey. Log terminates the next day 19th Sept. 1849.

This cruise is notable for the mention of the occasional Right whale off our shores, one of the last reminders of their previous arrival on migration to V.D.L. and New Zealand.

N.B.: The mate (to divert comment from the time spent at anchor) made an entry on the rear end paper of the Log as under.

Summary by mate of cruising times and periods at anchor

1848 sailed 26th October
1849 7th Sep. 398 days from date of sailing, arrived Hobart T.
231 days under weigh
159 days at anchor.
Search in newspaper files and elsewhere does not say more than the arrival with Sperm oil (quantity not given).

SOME REFLECTIONS ON THE FOREGOING

Before proceeding to Part II of this Survey (the M.S.S. Logs and Journals etc. in the Crowther Collection) one may be pardoned for mentioning the following tentative hypotheses or conclusions suggested by the study of the material of Part I just completed.

Its compilation has proved to be far more tedious and time consuming than had been expected, due first to the fact that my actual period of study at the State Library is limited to a short portion of each forenoon, the remainder being given to the obligations of Practice at my rooms, domiciliary and hospital visits. Also my transcript in pencil and in fine miniscule writing have given Mrs V. Walker a very difficult task in rendering it into her admirable typescript. Again the sources of reference have on a number of occasions proved to be scattered, difficult to locate and with gaps in continuity. These remarks do not apply to the Archives proper, but to later accessions from such authorities as the Customs Department and the Marine Board.

From time to time too when detailed information in regard to the take of oil etc. in a whaler's cargo, in a customs return, would have been of great interest and assistance, an entry might read no more than a curt 'From the South Seas with oil'.

Starbuck in his authoritative history of the 'American Whale Fisheries' certainly had access to the U.S. Customs records, with detailed information as to the nature of the oil viz. Sperm or Black and the quantities taken in barrels and actual weights of whalebone meticulously given. Such entries also would occasionally provide information of whales seen and the localities, and from such facts often may be determined the qualities of the Master and crew and their work.

We do have at Hobart fortunately remarkable runs of bound volumes of the local press. From this source and especially from the files of the *Hobart Town Courier* and the *Hobart Mercury* much information is available.

When noticing the arrival of a whaler the shipping reporter, on occasion apart from the catch, sought for information or incidents of the voyage as accidents to boats and men in pursuit of the whales and fatalities when they occurred. They obtained too the names of Tasmanian ships (whalers) seen or spoken on the voyage and the localities of the meeting; from this information an estimate might be had of the degree of success of the ship spoken, her plans and when she might be expected to return to Tasmania.

One turned automatically to such sources as *the Memoirs of Captain Harry O'May*[1] and *Mr Will Lawson*[2], full of practical information and from their background so very largely inspired by the *M.S.S. Memoirs of Captain William McKillop* much of whose work[3], so accurate and well told, was incorporated.

The study of the actual Logs has not always been easy owing to the poor quality of the ink employed, more especially when one considers the affect of salt water and damp over a long period. This want of legibility has led to confusion of dates and even of the actual day of the week concerned, while occasional entries of names of localities and islands seen or visited have had to be guessed at.

None the less the effort and time spent has proved of much interest and has been especially rewarding in regard to the whalers, though a close examination of the small vessels employed in the timber trade between Tasmania, New Zealand and out ports of the Mainland Colonies are more than worthy of a study long over-

due. Indeed each of the Logs studied has its own fascinating personal interest.

From the whaling Logs of the local ships a definite pattern emerges which probably applies also to the whalers out of Sydney, and even New Zealand, after leaving their own whaling grounds.

The Hobart Town whalers on leaving Hobart appear to have followed this pattern.

Firstly a preliminary visit to the *Middle Grounds* north and east of Tasmania towards Norfolk Island and the vicinity of Lord Howe Island. Thus they 'worked up' their crews, taking the humble blackfish if no larger whales offered.

Secondly *on the Western Grounds* across the G. Australian Bight to the Researche Is., King George Sound, the Lewin, or a little more south to Chatham Island (not to be confused with the Chatham Group (E x S of New Zealand).

Thirdly Stewart Island and Foveaux Straits, New Zealand (Frank Bullen's 'Solander Grounds').

Here shelter was found in one of the inlets of Stewart Island and with favourable weather whales were taken in Foveaux Straits and off the Solanders or the nearby S.W. Coast of New Zealand. When practicable the whales taken were 'tried out' in a quiet anchorage at Stewart Island.

After the study of the foregoing Logs my impression is that at this period almost all the Hobart Town whalers eventually found themselves in this Solander area. Here there was always the chance of a Sperm whale although the fabulous numbers recorded by Frank Bullen in his classic 'Cruise of the Cachelot'[2], appears to have been represented, only by an occasional whale, or a small 'pod' of the Sperm variety. Nevertheless the lure was still very strong for our ships and if no whales were found in Foveaux Straits there was the adjacent S.W. and south coast of New Zealand to try and failing here, to move east again to the coasts of Tasmania, possibly taking a Sperm whale on passage, and put into Port Davey; where with favourable winds a passage could be made out of the port towards Researche Bay. Researche Bay was always a local centre; of whaling in the first (Bay whaling) phase 1803-1840 approx when the southern Right whale came into our bays and inlets to calve, migrating here yearly and feeding off the swarms of 'Brit' (whale food) that is still seasonal and now the main food of the mutton bird. The annual season for Black whales was June to December, but by 1840 the herds were so depleted that the industry died.

In its heyday, Researche Bay in V.D. Land and Bay of Islands, New Zealand were the most important centres in the Southern Hemisphere.

About 1840 the attention of our whalers was centred on the Sperm whale. Starbuck[1] noted its regular migratory habits in search of its feed the giant squid or octopus (found usually in the warmer oceans). In its migrations the Sperm whale follows this food and two routes pass[2], S.W. New Zealand and S.W. Tasmania when making north to warmer water. Thus when not pursuing the Sperm on the high seas our local whalers used to lay in Port Davey which supplied plenty of fresh water and wood, and occasionally news from Hobart Town when small ships came in for Huon pine. Here the whalers rested in heavy weather and with a shift of wind put to sea and with luck got a whale, brought it in and tried it out. One vessel the barque *Terror* (A) spent a great deal of time passing between Port Davey and Researche Bay and eventually did take a Sulphur bottom at the latter port. 1. The Americans appear to have made little use of Port Davey; the Bay of Islands, New Zealand being their favourite anchorage, although at times they used Port Davey to obtain news and supplies of water and wood. There was the added advantage that no port dues were required in Tasmanian out ports.

Having thus generalised on the short cruises of the Tasmanian whalers in contrast to the long voyages of the Americans to southern latitudes en route to the northern Berings Straits, it must be born in mind that the rule was not invariable.

Charles Seal did lay on his ships the *Prince Regent, Eamont,* the *Essex* and the *Litherland* for Berings Straits and in 1851 lost the *Eamont* on the coast of Japan. Eventually the crew, after long detention, sailed from Desima Island to Java in a Dutch ship and from Batavia home again.

W. L. Crowther, F.R.C.S., a Colonial Surgeon and as well a whale ship owner in 1858 laid on his ships the *Offley, Elizabeth Jane* and *Flying Squirrel* for Herds Island and the Kergulens for Sea Elephant oil, no luck favoured him and the voyage was a failure.

The New England (American) fishing industry from Nantucket Island had gradually extended west and then south in the Atlantic Ocean, and later round the Horn into the Pacific, wonderful voyages being made to New Zealand and the Bay of Islands for very large catches of oil and the American whalers came to far outnumber those of the other Maritime nations and the problem became where to find enough whales.

This question was closely examined in the first half of last century by Lt M. F. Maury, U.S. Navy. He commenced an intensive study of the whaling Logs preserved in the many Libraries, Museums and whaling institutes of the Eastern Sea Board of U.S.A. as well as those available elsewhere. Maury noted the locations and dates on which whales had been sighted pursued or taken by individual ships. From this data in 1857 he published a documentary whaling chart. Twenty-four years later Capt. A. Starbuck a retired whaling Master was approached by the Centennial Board (who were preparing a history of the Fisheries of the United States for the Centenary of 1776), and invited him to complete the whaling section. He produced a masterpiece that was published again in 1878 and yet again by S. C. Sherman in 1965.

It must be axiomatic that the outstanding works of Lt Maury U.S. Navy and Capt Alexander Starbuck's history of New England whaling 1876 were indispensable to the Masters of American whalers. The present

writer has used the latter's history constantly for reference and is aware of the small replica of Maury's chart used as end papers in the noble 3rd edition[5].

Only two whaling Logs of North American ships are available at Hobart. They are of intense interest and show the American strategy of planning a long voyage to a fixed destination selected in an area where whales were most likely to be found. In both these instances they sought the Bowhead whales at the extreme North Pacific ocean adjacent to Bering Strait. On the voyage out after taking on water etc. and perhaps a few hands at the Western Islands, whales were sought at such areas as Goughs Island, Tristan-D-Achuna in the South Atlantic and New Zealand. On the long voyage home, via the Horn, unless a full ship, whales would be lowered for as an opportunity occurred. The American Masters and crews showed the highest degree of daring, efficiency and persistency in pursuing their quarry.

Hobart Town whaling produced some excellent Masters. J. W. Robinson of the *Offley* and part owner of the *Othello,* the Bayley brothers of the *Runnymede* and *Flying Childers,* were consistently successful; also Kennedy of the *Asia,* Folder and McGregor. All were able to conduct long series of good voyages *Had they possibly access to the works of Maury and Starbuck?* There is no hint or evidence that they had discovered and kept secret any special locality where whales might be found, but on the other hand I do not seem to remember their ships being logged as having been seen or spoken in the areas commonly used by Tasmanian ships whose Logs have been considered in this Survey.

In all, the impression is that the huge American whaling fleets, intensely competitive, produced an elite of hard driving specialists, whereas the Colonial whalers had little personal pride in the calling and joined in by chance and when in need of a job.

So our ships did not produce the *exceptionally skilled* boat steerers and junior mates or the individual crews described by Herman Melville in *Moby Dick.* Again whales were not taken just by chance and the Colonial mates could not drive their crews nor in a hard voyage or hard weather force them into a position to strike and make a kill.

Finally the Logs considered cover in part at least the period of decline and finish of the Sperm whale industry from Hobart and elsewhere. In the late seventies the *Offley* was hard put to find a crew and by 1886 only 4 ships, the *Waterwitch, Marie Laure, Asia* and *Sapphire* were whaling out of the port.

On 2nd January 1899, the *Helen* commenced an adventurous voyage to the Campbell Island and returned with 73 tons of Black oil. It was the last voyage of the industry from Tasmania and the ship was badly strained and leaking. * (See note end of this section).

The *Helen* had been converted from a trader to a whaler for this one voyage. The last of the regular whalers was the *Waterwitch.* She had been launched from the Pembroke dockyard in 1820 as H.M.S. *Falcon.* After active service off the E. African coast she was sold and on 12th Aug 1862 came into the port at Hobart Town as a whaler under Capt. Harrison with 118 tons of Sperm oil and whalebone valued at £10,000. Acquired by McGregor Bros she came to be their most successful whaler, taking between 1886 and 1895 669 tons of oil, 5 tons of whalebone and 167 pounds loads of Ambergris. Her total sales of oil amounting to £23,780 with expenditure for refittings etc. £16,750. Her last voyage terminated in 1896 when she was tied up at the Princes Wharf where I remember seeing her, and she was broken up about the end of the century.

Hobart's last whaling association was with the Norwegian Pelagic fleet working the Ross Sea. Captain Larson, commanded the *Neilson Alonzo* and had with him a fleet of some 5-6 chasers (Pol. 1.11.111 etc.) each had a harpoon gun and having taken a whale towed the day's catch back to the mother ship to be flenzed. A number of young Tasmanians went south with her and on similar expeditions until the 1st World War broke out, now only the tradition and memories remain. Another factor may have been the very serious depletion of the whales themselves.

Some Sources Consulted

Primarily the State Archives and other Semi Governmental documents.

1. O'MAY, Capt. Harry
'Wooden Hookers of Hobart Town'
also has carded records C.1955.

2. LAWSON, Will
'Blue Gum Clippers', 1949
'Harpoons A'Hoy'
'Bill the Whaler,' 1943

3. McKILLOP, Capt. William C.
Typescript of his reminiscences. C1945.

4. BULLEN, Frank
'Voyage of the Cachalot', 2nd Edition 1899

5. SHERMAN, S. C.
'The Voice of the Whaleman' 1965

6. STARBUCK,
'The History of the American Whaling Industry', 2 vols. 1964 edition

7. RHODES, W. B.
Whaling Journal, 1965.

[*Manuscript received 1st May 1970*]

THE BATHYMETRY OF LAKE ST. CLAIR, WESTERN CENTRAL TASMANIA

By

Edward Derbyshire[1]

Communicated by Dr J. L. Davies

ABSTRACT

A bathymetrical survey of Lake St Clair, conducted in January 1965, is described, together with the method of construction of a bathymetric chart. The relationship of the morphology of the lake-bed to lithology, structure and the form of the Pleistocene St Clair glacier are discussed. A series of retreat stages of this glacier is deduced.

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INTRODUCTION

It is now over a century since the pioneer geologist, Charles Gould deputed his colleague Burgess to take soundings of Lake St Clair during his 'Exploration of the western country' (1860). Gould's map, re-drawn here as Figure 1, has remained the only record of the bathymetry and, as such, it has served as a basis for all discussions of the origin of the lake since that time.

While the lakes of the West Coast Range (Dunn 1894: Moore 1894) and the smaller lakes of the Central Plateau and the Cradle Mountain-Barn Bluff plateau were being described before the turn of the century as 'almost *prima facie* evidence of glaciation' (Montgomery 1894), the origin of the larger lakes was a more contentious topic. Johnston opposed a glacial origin for Lake St Clair, preferring to ascribe it to 'the original irregularities of surface' (1894, p. 142). However, Montgomery (1894) and Officer, Balfour and Hogg (1895), despite an earlier hesitation by Officer (1894), proposed the trough to be glacial. Thirty years later, Clemes (1924) firmly supported the glacial explanation, although he accounted for the greater part of the depth of the basin by glacial deposition at the southern end rather than by glacial overdeepening in bedrock. Throughout his published work, A. N. Lewis (e.g. 1933) accepted a glacial origin for Lake St Clair, stressing glaciation as at least a partial explanation of the shallow lakes of the eastern Central Plateau (Lewis 1939). The origin of these lakes is still not known with any certainty, although recent depositional evidence (Derbyshire 1968) appears to rule out late Pleistocene glacial erosion as a cause.

Lake St Clair has been discussed more recently in the context of the glaciation of the Du Cane Range and the western Central Plateau (Derbyshire 1963). While bedrock outcrops near Derwent Bridge were used to discount Clemes' view that the moraine barrage at the foot of Lake St Clair may be 400 to 500 feet thick, the maximum depth of the lake was overestimated at 700 feet, following Lewis (1939). The trough is shown as a piedmont rock basin on the Glacial Map of Tasmania (Derbyshire, Banks, Davies and Jennings 1965), the minimum extent of which was estimated on the basis of associated morphological evidence (notably shorelines of rock or drift). The extent of the rock basin is shown to be somewhat larger on the Glacial Map of Northwest-central Tasmania (Derbyshire 1968a), a revised estimate based on a preliminary appraisal of the echo-sounding profiles reported below.

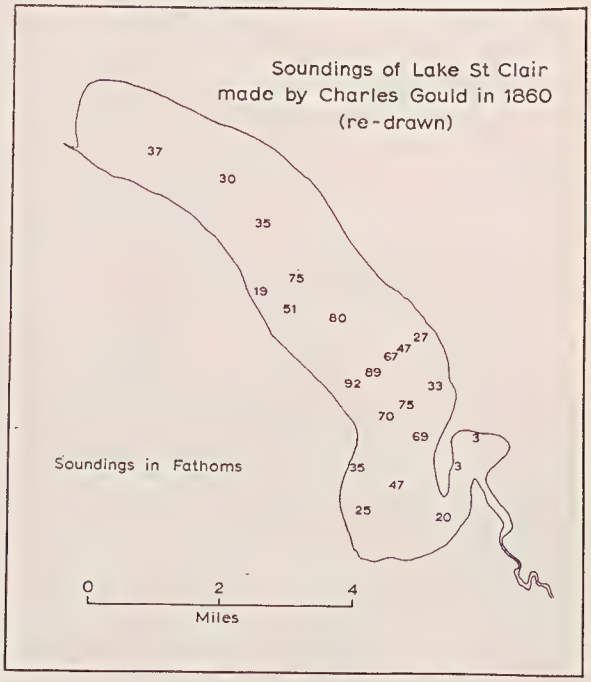

Fig. 1.—Charles Gould's line soundings of 1860.

THE BATHYMETRICAL SURVEY

In order to add to our knowledge of the morphology of glaciated surfaces and, in particular, to assess the degree of glacial overdeepening in the source areas of the Pleistocene glaciers, echo-sounding of many Tasmanian glacial lakes has been undertaken, the results of which will be published subsequently. Priority was given to Lake St Clair due to its relationships to the Central Plateau ice-dispersal area and its uniqueness as the deepest and only fully developed subalpine lake in Australia (Derbyshire and Peterson 1965).

For this echo-sounding programme, a portable device[1], transistorized and using battery power was employed, making possible the survey of a great variety of glacial

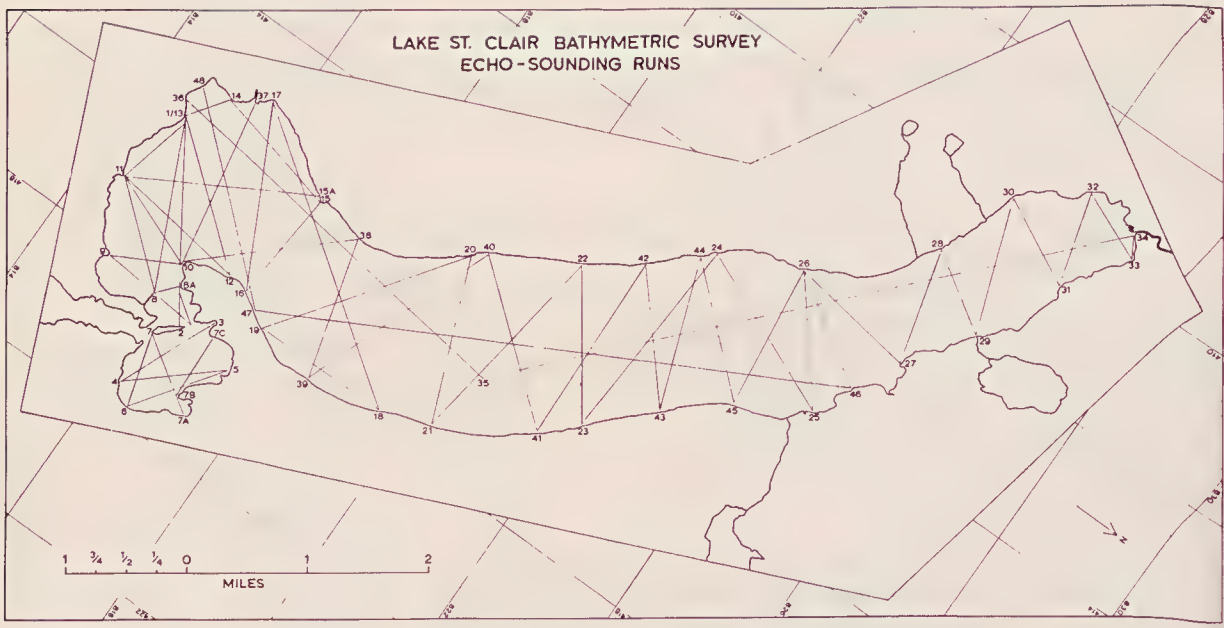

Fig. 2.—Map of echo-sounding traverses made during the bathymetric survey.

lakes. The instrument has four ranges and records continuously to a maximum depth greater than 900 feet in fresh water. The manufacturers quote an accuracy of ±5 per cent, which is greater than the fresh water-sea water adjustment (3 per cent: International Critical Tables 1929). The manufacturer's calibration is based on a velocity of sound of 4,900 feet per second in salt water which is the velocity at 12°C. As the only temperature data available for Lake St Clair is a surface record (2 to 3 feet depth) of 17°C on the day following the survey, direct adjustment of the calibration for temperature is not possible. However, the best means of calibrating echo-sounding equipment is by comparison of echo-profiles with known depths. Fortunately, some line soundings are available for Lake St Clair both published (Gould 1860) and unpublished. It was found that these compare very closely with the unmodified depths recorded during the survey. The greatest depth shown on Gould's map is 552 feet (92 fathoms: see Figure 1) while the echo-sounder recorded 546 feet in the same area of the lake. When it is considered that line sounding penetrates any fine bottom sediment not detected, except at shallow depth, by the echo-sounder, the correspondence may be regarded as very good.

The survey was conducted on January 5 and 6, 1965. Navigation was by the use of prominent landmarks and mountain peaks surrounding the lake, and distance was calculated by dead reckoning using uniform engine revolutions on and throughout all runs. In constructing the chart, allowance has been made for the fact that in leaving any shore station, the selected standard cruising speed was not reached until the first 50 yards had been traversed. The conditions on both days were windless and extremely calm.

1 The 'Koden' SR 385 recorder.

CONSTRUCTION OF THE MAP

The bathymetrical chart was constructed on the basis of 50 echo-profiles, totalling over 60 miles in length as shown in Figure 2. The reference datum, provided by the lake level on the days of the survey, was 2,406.0 feet a.s.l., *i.e.* 11.9 feet below the maximum water level imposed by the weir. This is within 1 ft. of the natural level of the lake before the installation of the weir. The datum, then, is essentially the same as in Gould's survey.

Few of the survey lines are spaced more than 400 yards apart and, at the southern end of the lake, spacing is generally much closer than this. Such coverage is sufficient to provide quite a detailed record of the subaqueous morphology of the lake basin.

Isobaths were drawn at 50 feet intervals on a dyeline base-map at 1:15,840 scale provided by the Department of Lands, Hobart. Isobaths at intermediate 25 feet intervals were then added in areas other than those with severe gradients. Isobaths at intervals of 10 feet were also drawn in for parts of the southern end of the lake, revealing some details of the lake-bottom moraine morphology (Fig. 3). These have had to be omitted from the general chart (Fig. 4) for reasons of scale. The detail shown on the bathymetric chart is, therefore, limited by considerations of scale rather than by deficiencies in the survey data. Cross-checking of depths at points of intersections of runs was generally very good, except for the southern side of the south-eastern peninsula where agreement was only moderate. This is, perhaps, to be expected for the subaerial morphology in this area is complex due to marked differential erosion of the jointed dolerite bedrock.

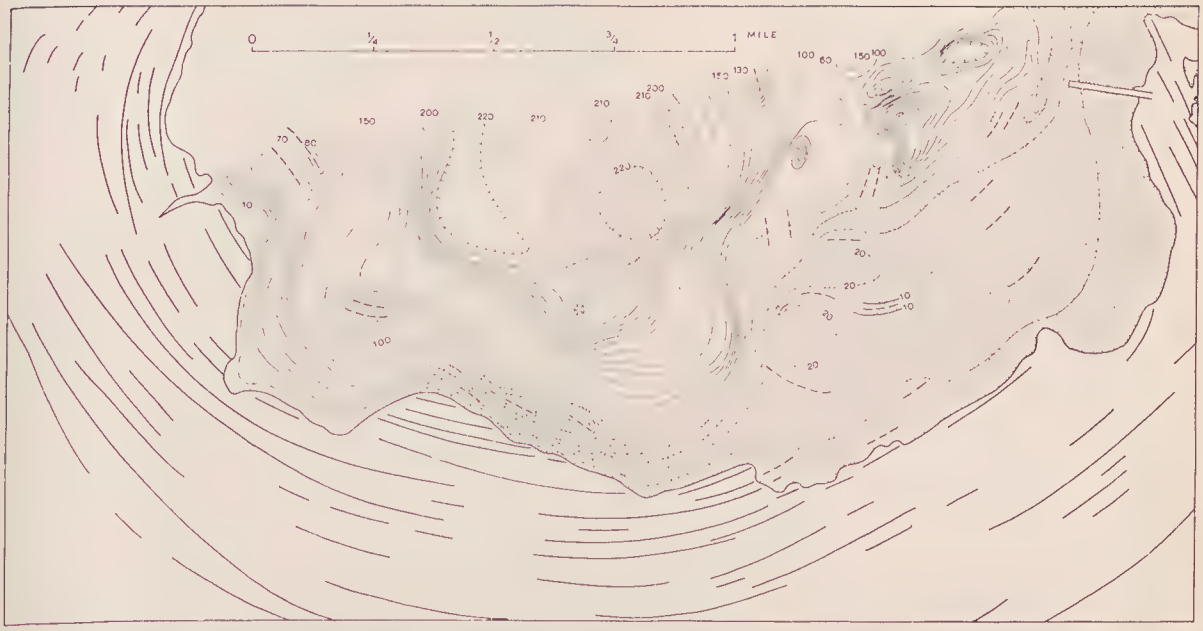

Fig. 3.—Bathymetric chart of the southern part of Lake St Clair, with isobaths at 10 feet intervals. Solid lines—moraine ridges on land; broken lines—submerged moraine ridges; stipple—unconsolidated deposits of the lake floor.

BEDROCK GEOLOGY

Well developed linear elements in the morphology of the district reflect the traces of faults and master joints. Erosion along one of the north to north-westerly faults typical of the western margins of the Central Plateau may account for the general orientation and form in plan of the Lake St Clair trough (Derbyshire, 1963). According to Gulline (1965), Lake St Clair lies along an inferred faulted junction between Permian rocks to the west and north and Jurassic dolerite to the east. The base of the dolerite sill rests on sub-horizontal Triassic and Permian sediments at approximately 4,000 feet on the eastern slope of Mt Olympus. On the eastern shore of the lake, however, the base of the dolerite is below lake level, having downthrown to the east. Accordingly, it is inferred that Permian sediments make up the bedrock floor of the western half of the lake and that Triassic or Permian sedimentary rocks may occupy most of the remainder.

While Lake St Clair lies in a true rock basin, bedrock is exposed along barely one sixth of the lake's 25 mile shoreline. It is best seen at the foot of glacially-oversteepened slopes on the north-west (Permian), south-west (Triassic) and south-eastern shores (dolerite of the south-eastern peninsula). The remainder of the shoreline is made up of a variety of deposits of Quaternary age, mainly tills but including also some washed sands and gravels and some talus and soliflual debris (Fig. 5).

THE MORPHOLOGY OF THE LAKE BASIN

Lake St Clair is an overdeepened basin of compound form. Details of its morphology are presented in Figures 3, 4 and 6. It will be seen that the lake occupies a large, elongated trough aligned N.N.W. to S.S.E., containing four distinct basins with closed contours at 265, 425, 530 and 220 feet depth (Fig. 6), in addition to a lateral basin on the south-east (Derwent Basin). The main trough is simple and remarkably straight, running along a bearing of 145°, between northings 815 and 825 rather to the west of the longitudinal axis of the lake. Complexities in the form of the basin are introduced by lateral elements, the most striking of which are the deep north-south tributary trough on the northern side of the lake along easting 414, the broad deep north and east of Cynthia Bay, and the large bedrock salient referred to here as the south-eastern peninsula. This salient is largely responsible for the complex outline and morphology of the southern end of the trough. The central part of the main trough is remarkably asymmetrical and stepped in transverse profile (Fig. 6), the generally steeper slopes lying consistently on the western side.

These morphological characteristics are the result of the interplay of two main factors, namely the bedrock structure and the behaviour of the Pleistocene glaciers. The outline in plan and the major morphological features of Lake St Clair appear to follow the alignment of two convergent faults, the greatest depths of the lake differing little from the location of these faults as inferred by Gulline (1965: cf. Fig. 4). The bathymetrical evidence suggesting the location of the fault trace is particularly clearly seen in some of the cross-profiles, especially numbers 38-39, 26-46 and 26-25, where the trough has the form of an asymmetrical V, with the steep limb on the west. All the transverse profiles are stepped below lake level, particularly profile 38-39, thus continuing the profile of the subaerial slopes developed on sub-horizontal Triassic and Permian rocks. This

Fig. 4.—Bathymetric chart of Lake St Clair. Isobaths at 50 feet intervals, with interpolated isobaths at intermediate (25 feet) intervals shown by broken lines.

suggests that these sedimentary rocks floor the lake on both sides of the inferred fault along the central trench. The widest, most clearly defined benches include one along the eastern side of the lake at a depth of 200-250 feet (profile 42-43, Fig. 6), those lying south-south-west of Mt Ida (50-100 feet depth: cf. profile 26-25, Fig. 6) and the one running southward along easting 417.

The tri-lobate form of the lake-head shoreline reflects the convergence at this point of three valley ice-streams down the Hamilton Creek, Marion Creek and Narcissus River troughs (Fig. 7). Even more striking is the broad embayment in the north-eastern shore where the ice-enlarged valleys on either side of Mt Ida converge as linear deeps below the present lake surface. This part of the lake is one of rapid southward increase in depth, constituting the northern margin of the main trench enclosed by the 400 feet isobath and containing the second and third closed basins (Figs. 4 and 6). While the general alignment of the main trench is controlled by faulting, as suggested above, its broadly arcuate form (most notable toward the south, with the greatest depths occurring where the lake basin narrows to less than one mile between the southern spur of Mt Olympus and the south-eastern peninsula) is clearly an expression of sculpture by a thick, vigorous but constricted glacier. To the south of this zone of constriction, however, the lake broadens rapidly and reaches a width of almost 3 miles. This terminal basin is compound (Figs. 3 and 4), consisting of Derwent Basin in the east and the main basin north and east of Cynthia Bay, as well as some restricted but deep enclosed depressions close to the south-eastern peninsula. The general form in plan of this terminal basin reflects the spreading of the 'expanded foot' of the St Clair glacier south of the zone of constriction, with associated reduction in lake depth and a shoreline whose constriction and form are largely dictated by a suite of end moraine ridges which can be followed below present water level (Fig. 3).

The echo-traces over a large part of the lake suggest that its bedrock floor has only a thin cover of sediments of little morphological significance. Two exceptions to this general statement should be noted, however. The first are the substantial ridges of probable end moraine origin, having a relative relief in excess of 20 feet. These are part of a much larger feature, the composite moraine barrage, which may reach the 90 feet isobath beneath Cynthia Bay, to judge from the echo-profiles (Fig. 8). This suggests that the moraine barrage is of the order of 130-150 feet in thickness in this area. Eastward, the total moraine thickness appears to be little more than 80 feet. Thus, moraines in the east are of smaller amplitude, both above and below lake water level.

The second exception is the broad bench, most of it lying at a depth of less than 25 feet, which occupies the south-east of the main terminal basin of Lake St Clair. In this area, in addition to some end moraine ridges, the echo-traces suggest that the remarkable uniformity of level is due to unconsolidated sediments up to 15 feet in depth, e.g., along profile 8-9 (Fig. 2). These sediments are predominantly of sand grade, as are the moraines on this south-eastern shore of the lake.

Elsewhere, the only notable area of unconsolidated deposits was found to be in the southernmost enclosed

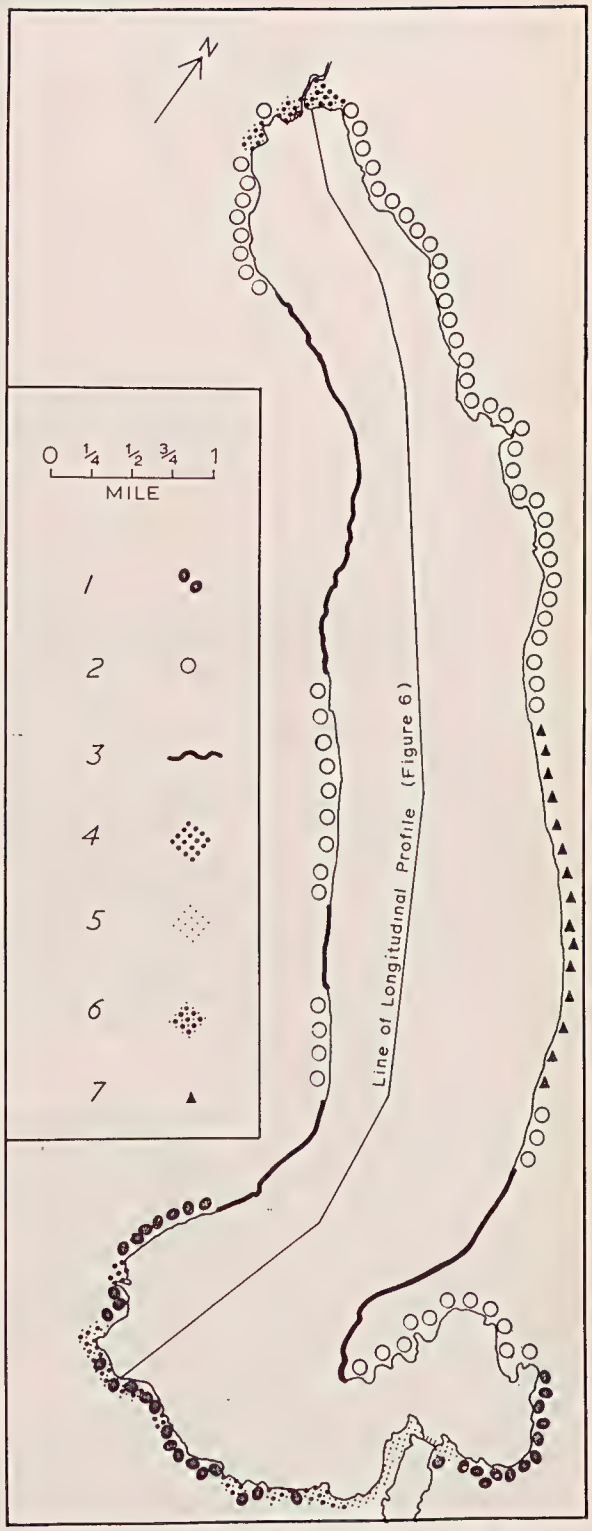

Fig. 5.—Materials making up the shoreline of Lake St Clair. 1.—'conglomeratic' till; 2.—till, undifferentiated; 3.—bedrock; 4.—gravel; 5.—sand; 6.—sand and gravel; 7.—talus,

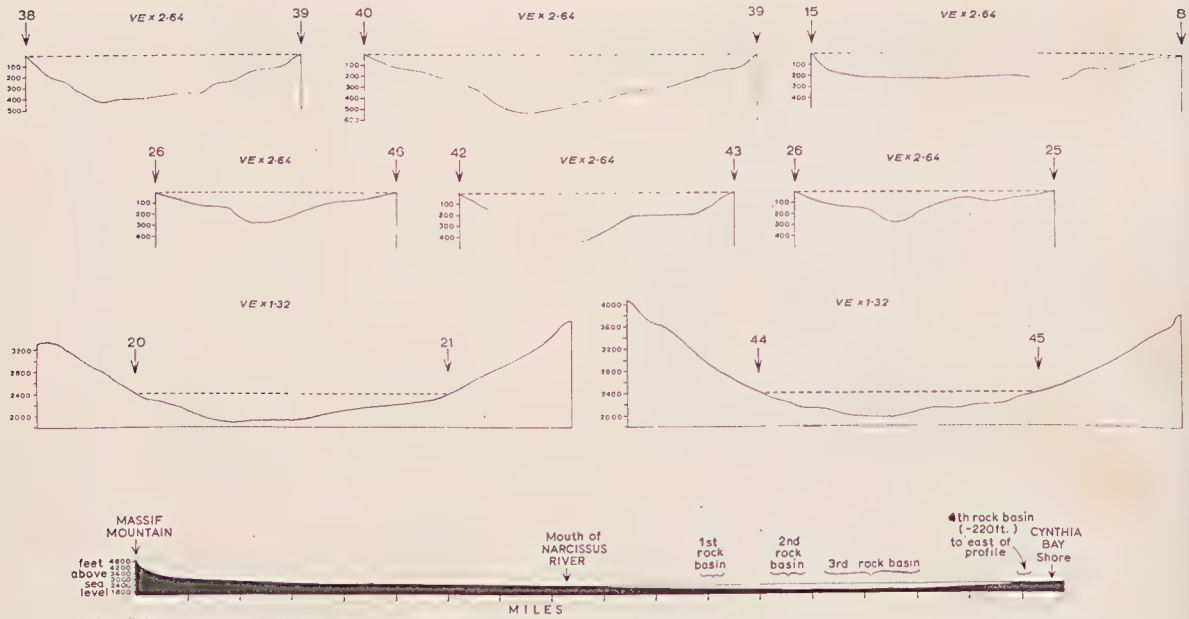

Fig. 6.—Selected transverse profiles and a longitudinal profile of Lake St Clair. Longitudinal profile is at natural scale.

basin of the main trough, where echo-sounding suggests thicknesses of superficial deposits of between 6 and 18 feet.

The steep-sided, deep but small closed basins near the south-eastern peninsula are taken to have been developed in well-jointed bedrock by locally severe glacial quarrying. These basins, and the good double echoes recorded at and below 48 feet on profile 11-12, suggest that the well defined break of slope at about 50 feet depth to be seen in the south-eastern part of the lake approximates the transition from a bedrock floor to a drift floor. If this is so, then of the total present lake volume of 1.6898 km^3, approximately 1.298 km^3 (76.83 per cent) is contained in a glacial rock basin.

DISCUSSION

The basin of Lake St Clair is a glacially-overdeepened reach of the Derwent River Valley. Notable modification by glacial erosion extends from the great valley-head cirque on the south-east slopes of the Du Cane Range southwards only as far as Bedlam Walls, and glacial depositional forms have been traced only a further 15 miles southwards to Mossy Marsh (Derbyshire, Banks, Davies and Jennings, 1965). While the course of the River Derwent appears little modified by Pleistocene glaciation south of Butlers Gorge, severe glacial overdeepening at Lake St Clair and locally thick glacial deposition to the south of the lake appear to have resulted in substantial modifications.

It may reasonably be inferred that the pre-glacial upper Derwent rose, as at present, in the Narcissus River valley and flowed south-eastward under the influence of a fault system. Severe glacial erosion broadened the upper valley to a catenary form and the subsequent glacial and glacifluvial deposition endowed it with a relatively flat floor, so that the Narcissus River now has a markedly underfit relationship to its valley. Convergence of three valley glaciers, the easternmost receiving substantial increments of ice from the western Central Plateau (notably by way of the twin outlet valleys about Mt Ida) resulted in overdeepening and the development of the main trench of the lake. Localization of the greatest depths of the rock basin in this locality was the direct result of the comparatively large reservoir of ice provided by the Central Plateau ice-sheet, the basin terminating only 1 to 2 miles south of the southern margin of the plateau. In the absence of such a reservoir, it appears unlikely that a rock basin of any great size would have developed. Despite its form and disposition, therefore, this subalpine basin is largely the product of sheet ice and not valley glaciers as normally understood.

The great depth of the moraine barrage on the south and south-west shores of the lake implies a southerly extension of the rock basin. The form of the northern part of the Navarre Plains, which are made up of ill-drained glacial deposits of unknown depth bounded sharply on east and west by the bedrock slopes of Bedlam Walls and Mt Rufus respectively, is consistent with such an extension although proof must await the results of seismic surveying.

The present Derwent River, which drains Lake St Clair by way of the Derwent Basin where it breaches the lower moraines typical of the eastern side of the lake foot, flows across glacial and glacifluvial drift as far as Derwent Bridge. Just south of this point, it turns westwards and cuts into a low ridge of dolerite joining Bedlam Walls and Mt Charles, creating a short gorge section between 35 and 50 feet deep. Beyond, it traverses

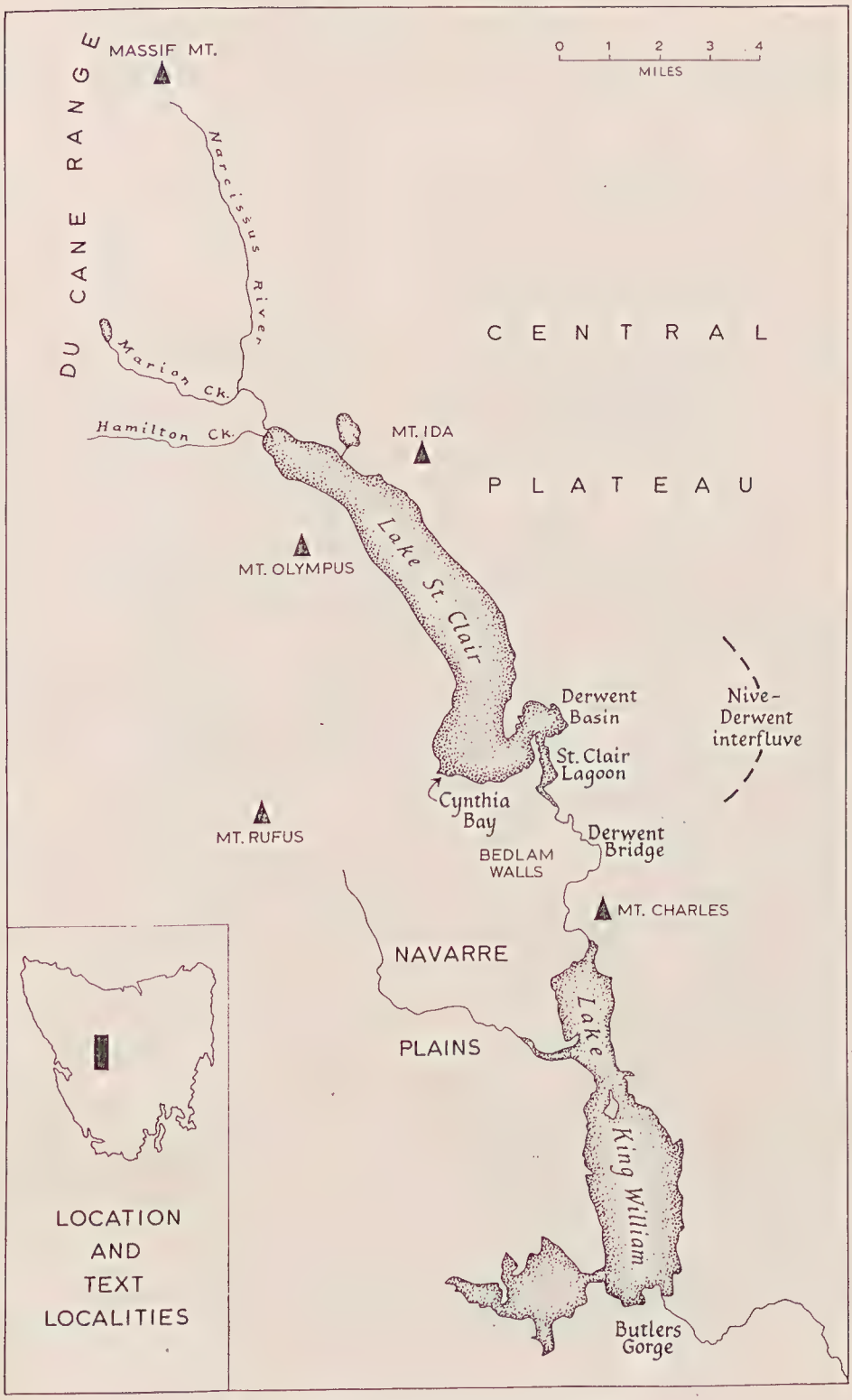

Fig. 7.—Location map of the Lake St Clair district.

a small glacifluvial outwash plain composed of washed sands and gravels with some intercalated rhythmites and some moraine remnants, its banks still being made up of glacial deposits as it descends below the level of the artificial Lake King William.

On the basis of evidence presented elsewhere (Derbyshire, 1963, 1968a: Derbyshire, Banks, Davies and Jennings, 1965), it appears that the route of the present upper Derwent immediately south of Lake St Clair was established by the glacial meltwaters of the down-wasting St Clair glacier. By the time its snout had retreated to the latitude of Mt Charles, the glacier was asymmetrical, its surface being lower in the south-east than in the south-west, thus concentrating meltwater effects in the area of the eastern basin. The moraine ridges, some composed entirely of bedded sands, and the broad, sand-covered floor of the south-eastern bay of the lake are consistent with this interpretation. With a thicker ice lobe to the south-west over the Navarre Plains, the more direct route for meltwater across this gentle plain was not developed, ice gradients and, hence, hydrostatic pressures within the glacier leading englacial and subglacial meltwaters south-eastward to swell the proglacial drainage. The Derwent's gorge section may well have been created at a relatively early stage in the deglaciation by the superimposition of englacial and subglacial drainage across a low point in the ridge. Whether the broad valley containing the Navarre Plains sediments represents the glacially-modified course of the pre-glacial Derwent River is not yet known, but the possibility is worthy of investigation by seismic refraction methods.

Finally, some stages in the evolution of the southern margins of Lake St Clair may be suggested (Fig. 9). The first stage appears to have been one of stillstand of the ice marked by substantial end moraines left by a western lobe which reached the Navarre River, and by an eastern lobe which stood at the Nive-Derwent interfluve. Both during this stage and in the subsequent frontal retreat of the eastern lobe, some ponding of meltwaters occurred, resulting in thick deposits of massive clay-silts to the east of the retreat moraines (l, la, lb on Fig. 9). The gentler gradients of the eastern lobe of the St Clair glacier are reflected in the greater spacing of contemporaneous end moraines in the east relative to the west (cf. Fig. 3, and Derbyshire, 1968a). Thus it may be postulated that, even in the early stages meltwater was guided eastward within thinner ice so that the Derwent gorge may have been initiated as a subglacial drainage line. This was uncovered as a subaerial meltwater route by stage 2, the present course of the Derwent north of Derwent Bridge becoming established, after the abandonment of three easterly channels, between stages 2 and 4. Stage 4 saw the ponding of meltwater in the eastern part of the present Derwent Basin and between moraines on either side of St Clair Lagoon. This enlarged south-easterly embayment of the proto Lake St Clair lasted until at least stage 5, and possibly much longer, for lowering to the present lake level necessitated at least 20 feet of incision into a stiff grey till containing abundant large boulders. It is under such conditions that the deposition of the thick, grey clay-silts (Derbyshire 1963, 1968a) in the inter-morainal swales is envisaged. The St Clair glacier-front retreated below present water level, in at least two stages as indicated by end moraine remnants (Stages

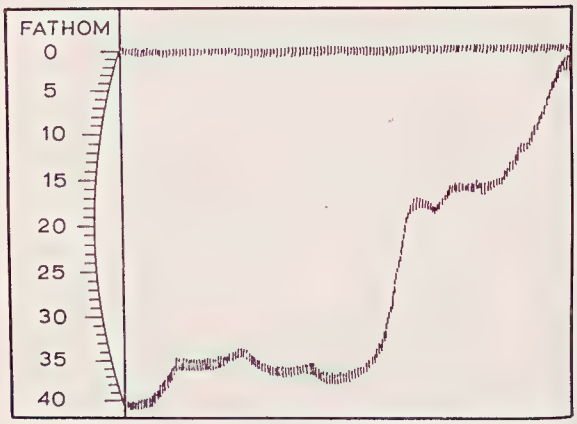

Fig. 8.—Echo-trace of the southern part of run 47-48 (see Fig. 2), showing bottom morphology of Cynthia Bay, including subaqueous moraine ridges.

6 and 7, Fig. 9). It is notable that, even at stage 6, the west to east gradient of the ice surface appears to have been maintained. An eighth stage is suggested, based on the gradient of a lateral moraine declining southward between 3,600 and 3,200 feet a.s.l. at 417822 (Fig. 4). By this stage, the ice tongue must have had a floating terminus, for it lay in 400 feet of water. Floating blocks of ice can be expected to have persisted for many seasons on the lake waters, for the snout of the St Clair glacier appears to have retreated slowly but regularly a further 14 miles northward into the Narcissus trough-end (Derbyshire, 1968a). Such floating lake ice may have been instrumental in the breaching of many moraine ridges, especially east of Cynthia Bay, that part of the moraine-girt lakeshore with the longest fetch for winds between west and north.

REFERENCES

CLEMES, W. H., 1925: Notes on a geological reconnaissance of the Lake St Clair district. *Pap. Roy. Soc. Tasm.*, 1924, pp. 59-72.

DERBYSHIRE, E., 1963—Glaciation of the Lake St Clair district, west-central Tasmania. *Aust. Geogr.*, **9**, pp. 97-110.

————, 1968: Two gelifluctates near Great Lake, central Tasmania. *Aust. J. Sci.*, **31** (4), pp. 154-6.

————, 1968a: Glacial map of N.W.-central Tasmania. *Record, Geol. Surv. Tasm.*, **6**, 41 pp.

————, BANKS, M. R., DAVIES, J. L., and JENNINGS, J. N., 1965: Glacial Map of Tasmania. *Roy. Soc. Tasm., Spec. Pub.* **2**, 11 pp.

————, and PETERSON, J. A., 1965: Distribution and morphology of some Tasmanian lakes. *Aust. Soc. Limnol., Newsletter*, **5** (1), pp. 5-8.

DUNN, E. J., 1894: Glaciation of the Western Highlands, Tasmania. *Proc. Roy. Soc. Vic.*, **6** (n.s.), pp. 133-8.

GOULD, C., 1860: Exploration of the Western Country. *Tasm. Parl. Pap.*, 1860, **6.**

CULLINE, A. B., 1965: St Clair. *Explan. Rept Geol. Surv. Tasm.*, 1-mile Geol. Map Ser. K/55-10-59.

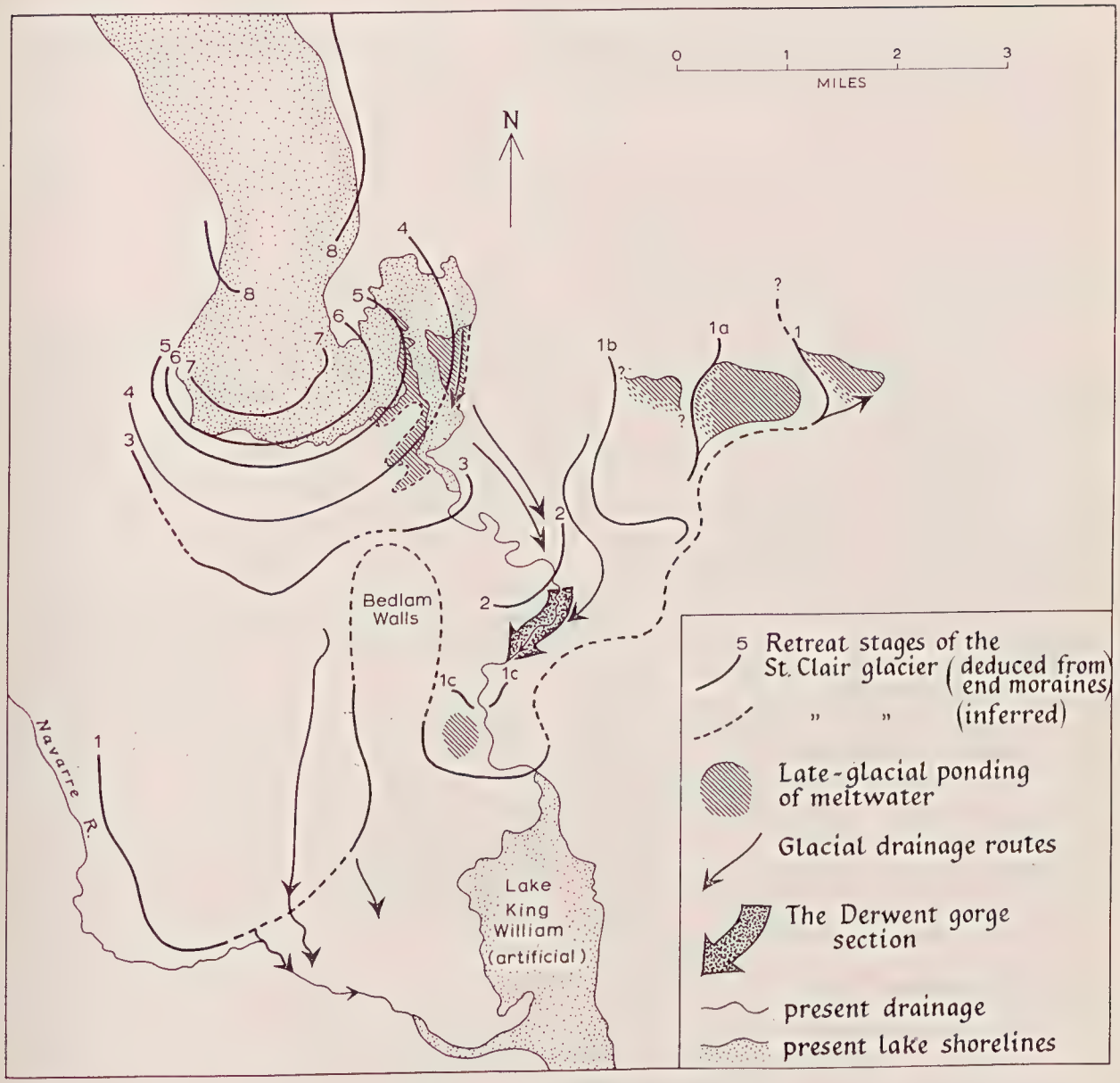

Fig. 9.—Some retreat stages of the St Clair glacier.

JOHNSTON, R. M., 1894: Notes on the geology of Lake St Clair and its immediate neighbourhood, together with observations regarding the probable origin of our numerous Tasmanian lakes and tarns. *Pap. Roy. Soc. Tasm.*, 1893, pp. 135-46.

LEWIS, A. N., 1933: Note on the origin of the Great Lake and of other lakes of the Central Plateau. *Pap. Roy. Soc. Tasm.*, 1932, pp. 15-28.

————, 1939: Notes on Pleistocene glaciation, Mount Field to Strahan. *Pap. Roy. Soc. Tasm.*, 1938, pp. 161-73.

MONTGOMERY, A., 1894: Glacial action in Tasmania. *Pap. Roy. Soc. Tasm.*, 1893, pp. 159-69.

MOORE, T. B., 1894: Discovery of glaciation in the vicinity of Mount Tyndall, in Tasmania. *Pap. Roy. Soc. Tasm.*, 1893, pp. 147-9.

OFFICER, G., 1894—The geology of the Lake St Clair district. *Pap. Roy. Soc. Tasm.*, 1893, pp. 150-8.

OFFICER, G., BALFOUR, L., and HOGG, E. G., 1895: Geological notes on the country between Strahan and Lake St Clair, Tasmania. *Proc. Roy. Soc. Vic.*, 7 (n.s.), pp. 119-30.

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STYLONISCIDAE (ISOPODA, ONISCOIDEA) FROM TASMANIA AND NEW ZEALAND

By

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Tasmanian Museum and Art Gallery, Hobart
(With five plates)

ABSTRACT

An earlier discussion of genus *Styloniscus* is revised. Tasmanian forms previously identified as *St. thomsoni, St. phormianus* and *Notoniscus australis* are recognized as new species and information on the above-named New Zealand species is given. One other new species of *Styloniscus* from Tasmania is described. Variation among New Zealand examples of *St. otakensis* is discussed and a typical form of this species is determined. The occurrence of *St. nichollsi* in caves is recorded. Supplementary type specimens are selected for *Notoniscus tasmanicus.*

MATERIAL AND METHODS

Where no acknowledgement to a collector is given in the text, the material described was collected by the author. Specimens have been preserved in 80% alcohol. Objects examined microscopically have been mounted in 'Euparal' mountant.

Length of an animal is measured from anterior border of cephalon to posterior border of telson; breadth is measured across 4th segment of pereion.

Descriptions of new species

The descriptions of certain structures of *Styloniscus maculosus,* as given by Green (1961, pp. 277-80), apply equally well to the corresponding parts of the three new species of *Styloniscus* described in the present paper. Such accounts have not been repeated here. The structures of *St. sylvestris, St. hirsutus* and *St. planus,* n.spp., for which the corresponding descriptions of *St. maculosus* apply, are as follows:

lines and lobes of cephalon,
left and right mandibles,
1st and 2nd maxillae,
1st - 3rd pereiopods of male and female (except that hyaline scales absent from 3rd pereiopod of male in *St. sylvestris),*
male organ,
protopodite and muscles of 1st pleopod of male,
exopodite of 2nd pleopod of male,
1st pleopod of female.

GENUS *STYLONISCUS* Dana

Styloniscus Dana, 1852, p. 302.

For synonymy and generic diagnosis, see Vandel (1952, p. 14), followed by Green (1961, p. 267).

Revision of previous notes

In an earlier study of *Styloniscus* (Green, 1961, p. 267) two new Tasmanian species, *St. maculosus* and *St. squarrosus,* were distinguished from established species by means of two keys. These did not take into account further work on *Styloniscus* by Barnard (1958, p. 71) and Andersson (1960, p. 544).

In the first key (p. 270), the name *'mauritiensis',* standing for *St. mauritiensis* (Barnard, 1936), in fact represented *St. vandeli* Barnard, 1958, while *St. mauritiensis* and *St. albidus* Vandel, 1952 (the latter raised to specific rank by Barnard), were omitted from the key. *St. maculosus* and *St. squarrosus* are distinct from *St. mauritiensis* and *St. albidus* because of differences in the arrangement of the ocelli.

With regard to the second key (p. 271), some of the characters obtained from descriptions by Verhoeff (1939, 1951) have been discredited by Andersson. Of the six species erected by Verhoeff (1939), only *St. pallidus* and *St. simrothi* remain well established. *St. nordenskiöldi* and *St. iheringi* have been suppressed in synonymy by Andersson, a procedure supported by Vandel (1963, p. 67). The position of *St. araucanicus* and *St. schwabei* is less clear. Andersson believed these two forms to be conspecific, but not identifiable with *St. magellanicus* Dana, 1853, while Vandel (1963, p. 67) considered that they may be synonymous with *St. magellanicus.* Because of their uncertain identity, *St. araucanicus* and *St. schwabei* have been omitted from further discussion in the present paper. The two Tasmanian species established in 1961 remain distinct from *St. pallidus* and *St. simrothi,* on the form of the 7th pereiopod and 1st pleopod of the male in the case of *St. maculosus,* and on the nature of the dorsal surface of the body in the case of *St. squarrosus.*

Finally it should be noted that *St. australis* (Dollfus, 1890), which was doubtfully included in *Styloniscus,* has been redescribed by Barnard (1965, p. 203) and placed definitely in this genus.

New species

Also in the previous study of *Styloniscus,* examples of two other Tasmanian forms were identified (on comparison with published descriptions) as belonging to *St. thomsoni* (Chilton, 1885) and *St. phormianus* (Chilton, 1901), both species established on material from New Zealand. Since then it has been possible to collect samples of these latter two species in New Zealand and to compare them directly with Tasmanian material. As a result the Tasmanian forms have been separated as new species; *St. thomsoni* Green becomes *St. sylvestris,* n.sp., and *St. phormianus* Green becomes *St. hirsutus,* n.sp. A third new species, *St. planus,* n.sp., has been found in Tasmania.

TABLE 1. DIFFERENCES BETWEEN SPECIES OF *STYLONISCUS*

\+ signifies presence of a character,
— signifies its absence.

Species	Long setae on cephalon and pereion	Setae on flagelliform process of endopodite of 1st ♂ pleopod	Incurved sternal border on ischion of 7th ♂ pereiopod	Setose tubercle on propodos of 7th ♂ pereiopod
phormianus	+	—	—	—
hirsutus	+	—	—	—
thomsoni	—	+	—	+
sylvestris	—	+	—	—
maculosus	—	+	+	—
magellanicus	—	—	+	+
planus	—	—	+	+
pallidus	—	—	—	+
simrothi	—	—	—	+
nichollsi	—	—	—	+

St. sylvestris, St. hirsutus and *St. planus* share the following characters:

dorsal surface of cephalon and pereion smooth;
ocelli of eye separated and arranged in a triangle.

Thus they are distinct from the established species listed below, each of which possesses one, or both, of the contrasting characters:

dorsal surface of cephalon and pereion tuberculate, granulate or strongly spinescent;

ocelli of eye contiguous and/or arranged in a line.

St. australis (Dollfus, 1890); *St. otakensis* (Chilton, 1901); *St. verrucosus* (Budde-Lund, 1906); *St. spinosus* (Patience, 1907); *St. tabulae, St. hottentoti, St. natalensis, St. ventosus, St. capensis, St. moruliceps, St. austro-africanus, St. georgensis, St. horae, St. cestus, St. swellendami, St. riversdalei,* all (Barnard, 1932); *St. mauritiensis* (Barnard, 1936); *St. albidus* Vandel, 1952; *St. vandeli* Barnard, 1958; *St. squarrosus* Green, 1961; *St? murrayi, St? monocellatus,* both (Dollfus, 1890); *St? kermadecensis* (Chilton, 1911); *St? commensalis* (Chilton, 1910).

The position of *St. jeanneli* (Paulian de Félice, 1940) in this grouping is uncertain, as the dorsal surface in this species is uneven, sometimes covered with small tubercles. However non-tuberculate specimens of *St. jeanneli* would still be distinct from the three new Tasmanian species on the shape of the endopodite of the 2nd male pleopod.

This leaves the following species to be considered: *St. magellanicus* Dana, 1853; *St. thomsoni* (Chilton, 1885); *St. phormianus* (Chilton, 1901); *St. pallidus, St. simrothi,* both (Verhoeff, 1939); *St. nichollsi* Vandel, 1952; *St. maculosus* Green, 1961. Differences between these and the new species are shown in Table 1. Further discussion of taxonomic differences follows the description of each new species.

Key to species of *Styloniscus* represented in Tasmania

1. Dorsal surface of cephalon and pereion with transverse rows of conspicuous, rounded tubercles —— *squarrosus.*
   Dorsal surface of cephalon and pereion smooth, or slightly uneven, but not conspicuously tuberculate —— —— 2.
2. Cephalon and pereion with numerous long setae which project laterally beyond outline of body — *hirsutus.*
   Cephalon and pereion with few or no long setae —— 3.
3. Second article of endopodite of 2nd male pleopod with inner side curved in abruptly at about one-quarter of its length from apex, so that its apical part is asymmetrical, continuous with outer half of endopodite —— *nichollsi.*
   Second article of endopodite of 2nd male pleopod with apical part almost symmetrically aligned with remainder of endopodite —— —— —— —— —— —— —— 4.
4. Propodos of 7th male pereiopod with a setose tubercle on posterior surface; endopodite of 1st male pleopod without setae —— —— —— —— —— —— —— *planus.*
   Propodos of 7th male pereiopod without such a tubercle; endopodite of 1st male pleopod bearing setae — 5.
5. Ischion of 7th male pereiopod with sternal border straight; flagelliform process of endopodite of 1st male pleopod with setae restricted to a tuft at apex —— —— *sylvestris.*
   Ischion of 7th male pereiopod with sternal border incurved; flagelliform process of endopodite of 1st male pleopod with distal quarter setose and 3 setose pencils at apex —— —— —— —— —— —— —— *maculosus.*

STYLONISCUS THOMSONI (Chilton)
(Figs 1-4)

Philougria thomsoni Chilton, 1885, p. 576.
Philygria thomsoni Chilton, 1886, p. 159.
Trichoniscus thomsoni Chilton, 1901, p. 118.
Trichoniscus (Megatrichoniscus) thomsoni Jackson, 1938, p. 176.
Patagoniscus thomsoni Verhoeff, 1939, p. 304.
Styloniscus thomsoni Vandel, 1952, p. 36.

Seventh pereiopod. One character shown by the author's specimens of *St. thomsoni* is not mentioned in previous descriptions. The ischion of the 7th pereiopod in the male has its sternal border straight, as in the female, but there is sexual differentiation of the propodos. A rounded, setose tubercle is present on the posterior surface of the propodos in the male; no such tubercle occurs in the female.

Habitat

Specimens examined in detail were collected from debris in mixed podocarp-hardwood forest (at sea level) at Papatowai, South Otago, N.Z., on 10.VIII. 1966; 6 males and 8 females.

Other specimens were found in southern beech forest near Lake Monowai, Fiordland, and in predominantly beech forest near Tuatapere, Southland. All localities are in the South Island of New Zealand.

STYLONISCUS SYLVESTRIS, n.sp.
(Figs 5-9)

Styloniscus thomsoni Green, 1961, p. 271.
—— *non* (Chilton, 1885).

Location of type specimens

Holotype male and allotype female in the Australian Museum, Sydney.

Paratype male and female in the Western Australian Museum, Perth.

Paratype male and female in the Tasmanian Museum, Hobart.

The description given by Green (1961, p. 271) is too brief to serve for a new species. A more detailed account is presented here.

Male

Size. Largest specimen: length 6.0 mm., breadth 2.7 mm.

Colour. Background coloration of live animal is variegated; predominant colours are light brown with dark brown, or orange-brown with dark brown, or reddish with dark areas almost black. Unpigmented patches present, but not especially conspicuous.

Cephalon. Surface of vertex smooth; scale-setae like those on pereion. Eyes (fig. 5) each composed of 3 ocelli, separated from one another and arranged in a triangle. Distances between ocelli not quite equal; posterior two ocelli closer to each other than either is to anterior ocellus. Lower two ocelli set on a slight swelling at side of cephalon.

Second antenna. Length of peduncle 1.85 mm., length of flagellum 0.68 mm. Fifth article of peduncle has tubercles arranged in two rows, 3 in dorsal and 2 or 3 in ventral row; each tubercle bears a group of long scales. Flagellum has 6 articles. (In smaller specimens flagellum has 5 or 4 articles).

Maxilliped. Endopodite (excluding ischion, which is distinct) divided on inner side into 4 lobes. A faint, oblique suture line extends across ventral surface from notch between 2nd and 3rd lobes. In other respects, maxilliped is as described for *St. maculosus* (Green, 1961, p. 278).

Pereion. Posterior angles of 1st and 2nd epimera bluntly rounded, those of 3rd epimera right-angled and rounded. Fourth to 7th epimera produced backwards and progressively more acute. Dorsal surface of pereion smooth. Scale-setae each with scale part long and narrow, spiniform. Tergites covered with pointed, simple scales.

Seventh pereiopod. Ischion (fig. 6) has sternal border straight; lower part of ischion not prolonged distally below meros. An acute, triangular lobe projects from upper surface of ischion. No setose tubercle on propodos.

Pleon. Abruptly narrower than pereion. Third to 5th pleura small, acute. Telson trapezoidal with posterior border straight; two scale-setae, each with scale part broad, subtriangular and sharply pointed at apex, project beyond posterior border. Dorsal surface of pleon smooth.

First pleopod (fig. 7). Exopodite subtriangular with outer border not indented. Endopodite subcylindrical, tapering, with a terminal flagelliform process. At apex of latter (fig. 8) is a short, dense tuft of setae, flanked on either side by a small, pointed extension of process itself. Combined outline of these apical structures is bluntly rounded. No other setae on flagelliform process, apart from apical tuft.

Second pleopod (fig. 9). Length of articles of endopodite: 1st 0.28 mm., 2nd 1.16 mm. Second article styliform, tapering to an acute apical part, scarcely bent outwards. An oblique groove of varying width, with strongly chitinized walls, extends down dorsal surface of article. In middle part of its length, outer wall of groove bears stiff setae. On ventral surface, at two-fifths of length of article from apex, an oblique ridge of chitin projects outwards. Beyond this ridge article tapers more markedly, then widens again slightly before terminating in a sharp point. Between oblique ridge and apex, article is ornamented with longitudinal ridges of chitin.

Fifth pleopod. Groove for endopodite of 2nd pleopod extends through most of length of exopodite; region occupied by groove more darkly pigmented than remainder.

Uropod. Length of articles: protopodite 0.43 mm., exopodite 0.93 mm., endopodite 0.55 mm.

Female

Size. Largest specimen: length 6.7 mm., breadth 3.1 mm.

Female differs from male in the following structures:

Second antenna. Flagellum may have 7 articles.

First and 2nd pereiopods, 1st pleopod. (As described for *St. maculosus).*

Seventh pereiopod. No prominent lobe on ischion. (An earlier claim (Green, 1961, p. 271) that 7th pereiopod is without sexual differentiation is corrected).

Second pleopod. Endopodite conical and elongated, its distal two-thirds bearing comb-setae. Length of exopodite approximately two-thirds that of endopodite; length (along inner border): exopodite 0.44 mm., endopodite 0.63 mm.

Fifth pleopod. Exopodite without groove or its associated band of darker pigment.

Habitat

Type locality. Description is based on specimens found in debris and under decaying wood in forest, dominated by eucalypts but with the inclusion of some myrtle (southern beech), on Mt Wellington, Tasmania.

Type specimens have been selected from a collection of 26 males and 34 females, obtained on 26.VI.1957, from debris beside Shoobridge Track (altitude 580 m.). Paratype slides have been prepared from this and the

Figs 1-4.—*Styloniscus thomsoni* (Chilton).

Fig. 1.—Right side of cephalon, dorso-lateral view, showing three ocelli and antennary tubercle (antennae removed).
Fig. 2.—Distal part of left 1st pleopod of male, dorsal view.
Fig. 3.—Apex of endopodite of left 1st pleopod of male, ventral view.
Fig. 4.—Right 2nd pleopod of male, dorsal view.

Figs 5-9.—*Styloniscus sylvestris*, n.sp.

Fig. 5.—Right side of cephalon, dorso-lateral view, showing three ocelli and antennary tubercle (antennae removed).
Fig. 6.—Meros and ischion of right 7th pereiopod of male, anterior view.
Fig. 7.—Distal part of left 1st pleopod of male, dorsal view.
Fig. 8.—Apex of endopodite of right 1st pleopod of male, ventral view.
Fig. 9.—Left 2nd pleopod of male, dorsal view.

following earlier collections: beside Shoobridge Track, on 6.III.1957, 8 males and 11 females; near the Pinnacle Road (altitude 820 m.), on 15.V.1956, 2 males and 9 females, and on 22.X.1956, 3 males and 9 females. Collectors on 15.V.1956 were Professor V. V. Hickman, Dr J. L. Hickman and the author.

Other specimens have been collected higher on Mt Wellington at an altitude of 1,130 m.

Other localities. Specimens were found under decaying wood and in forest debris near Collinsvale, at Tarraleah, in Mt Field National Park and in the Florentine Valley.

Remarks

On the basis of a comparison with published descriptions, the Tasmanian isopods now named as *St. sylvestris* were previously (Green, 1961) identified as *St. thomsoni* (Chilton). The subsequent examination of specimens of *St. thomsoni* from New Zealand has shown that this identification was not justified, although the two species are similar.

A detailed comparison has been made between type material of *St. sylvestris* from Mt Wellington, Tasmania, and examples of *St. thomsoni* collected at Papatowai, New Zealand. Differences listed in Table 2 are those which best serve to distinguish the species from each other.

With examples of the two species placed side by side, other relative differences are apparent. The antennary tubercles of *St. sylvestris* are more prominent than those of *St. thomsoni*. In both species the three ocelli of the eye are arranged in a triangle and widely separated, with unequal distances between them; however in *St. sylvestris* (fig. 5) the forward displacement of the anterior ocellus from the posterior two ocelli is less than it is in *St. thomsoni* (fig. 1). The articles of the endopodite of the 2nd male pleopod in *St. sylvestris* (fig. 9) are broader in proportion to their length than is the case in *St. thomsoni* (fig. 4); however details in the structure of these endopodites are similar in the two species.

In spite of the differences which occur, morphological similarities between *St. thomsoni* and *St. sylvestris* are striking and seem to indicate that these two species are more closely related to one another than each is to sympatric species of *Styloniscus* found in New Zealand and Tasmania respectively.

TABLE 2.

St. thomsoni (Chilton)	*St. sylvestris*, n.sp.
Pereion broad, so that length of animal is not more than twice its greatest breadth.	Pereion narrower, so that length of animal is more than twice its greatest breadth.
Largest specimens: male: length 5.0 mm., breadth 2.6 mm. female: length 8.3 mm., breadth 4.3 mm.	Largest specimens: male: length 6.0 mm., breadth 2.7 mm. *female: length 6.7 mm., breadth 3.1 mm.
Seventh pereiopod of male without a prominent lobe on ischion, but with a setose tubercle on posterior surface of propodos.	Seventh pereiopod of male with a triangular lobe on upper surface of ischion (fig. 6), but without a setose tubercle on propodos.
Flagelliform process of endopodite of 1st male pleopod with long apical setae, which together form a diamond-shaped, pointed mass (fig. 3).	Flagelliform process of endopodite of 1st male pleopod with short apical setae, which together form a crescent-shaped, bluntly rounded mass (fig. 8).

* Measurements of a female specimen given in 1961 (p. 272) have not been confirmed in the present study of *St. sylvestris*.

STYLONISCUS PHORMIANUS (Chilton)
(Figs 10-13)

Philougria rosea Chilton, 1883, p. 73 (in part)
—*non* Koch, 1835-44.
Philygria rosea Thomson and Chilton, 1886, p. 157 (in part).
Trichoniscus phormianus Chilton, 1901, p. 115.
Patagoniscus phormianus Verhoeff, 1939, p. 303.
Styloniscus phormianus Vandel, 1952, p. 47.

Supplement to Chilton's (1901) description

The following information is based on the author's specimens from Dunedin, N.Z.

Size. Largest male specimen: length 3.3 mm., breadth 1.6 mm. Largest female specimen: length 4.9 mm., breadth 2.3 mm.

Second antenna. Number of articles in flagellum is 4 in most males, 5 or 4 in most females, 3 in very small specimens.

Seventh pereiopod. No sexual differentiation.

Second male pleopod (fig. 12). Endopodite composed of two articles, not three as stated by Chilton (p. 117). Length of articles: 1st 0.16 mm., 2nd 0.48 mm.

Fifth male pleopod. Groove for endopodite of 2nd pleopod occupies about two-thirds length of exopodite.

Second female pleopod (fig. 13). Endopodite is more elongated than was figured by Chilton (pl. 12, fig. 1 plp. 2 ♀). Length of exopodite less than half that of endopodite; length (along inner border): exopodite 0.29 mm., endopodite 0.64 mm.

Habitat

Specimens studied in detail were obtained from debris in a mixed forest in the Town Belt, Dunedin, N.Z. (South Island; altitude 90 m.), on 30.VII.1964, 39 males and 94 females. Further collections from this locality were made on 12.IV.1965, 24.III.1966 and 12.XII.1966.

Other specimens of comparable size were found in forest debris: in the South Island at Papatowai, South

Otago, and near Tuatapere, Southland; on Stewart Island at Acker's Point and in Baker Park, both near Oban.

Larger specimens, one male and one female, were collected by Professor B. J. Marples, on I.III.1964, in forest near Otautau, Southland.

Large form of St. phormianus

Specimens from Otautau, N.Z.

Size. Male: length 5.8 mm., breadth 2.5 mm. Female: length 7.0 mm., breadth 3.6 mm.

These two large examples of *Styloniscus* have been assigned to *St. phormianus* as they show most of the characters of this species, including the presence of long setae on the cephalon and pereion and the form of the 1st and 2nd pleopods of the male. They differ from specimens found in Dunedin as follows:

Dorsal surface of cephalon and pereion with scattered, low tubercles. Flagellum of 2nd antenna of male with 6 articles (2nd antennae of female have been lost).

Chilton (1901, p. 115) described *Tr. phormianus* as having the dorsal surface 'smooth or with a few small granulations and irregularities'. Examples of *St. phormianus* from the North Island of N.Z., described by Vandel (1952, p. 50), had smooth integuments. Among the author's collections of *St. phormianus*, the dorsal surface of the cephalon and pereion is smooth in the specimens from Dunedin and Papatowai, almost smooth in those from Tuatapere and slightly tuberculate in those from Stewart Island. Thus the presence of scattered, low tubercles on the cephalon and pereion of the large animals from Otautau is a feature shared with some members of the smaller form of the species.

Chilton (1886, p. 160) referred to an unusually large specimen of *Philygria rosea* found at Kinloch (Central Otago). Presumably this represented another example of the large form of *St. phormianus.*

STYLONISCUS HIRSUTUS, n.sp.

(Figs 14-20)

Styloniscus phormianus Green, 1961, p. 273.
—*non* (Chilton, 1901).

Location of type specimens

Holotype male and allotype female in the Australian Museum, Sydney.

Paratype male and female in the Western Australian Museum, Perth.

Paratype male and female in the Tasmanian Museum, Hobart.

The description given by Green (1961, p. 273), based on specimens from Collinsvale, Tasmania, is too brief to serve for a new species. A more detailed account, presented here, is based on a larger collection from Mt Wellington.

Male

Size. Largest specimen: length 2.0 mm., breadth 0.8 mm.

Colour. Dorsal surface of live animal purplish-brown, mottled with unpigmented patches.

Cephalon. Surface of vertex smooth, bearing scattered, long setae. Each eye composed of 3 ocelli, separated from one another and arranged in a triangle. Ocelli set in two or three spots of black pigment; in former case, one black area surrounds the two posterior ocelli.

Second antenna (fig. 14). Length of peduncle 0.53 mm., length of flagellum 0.14 mm. On outer surface of 5th article of peduncle are 6 long spines (4 dorsal, 2 ventral), not raised on tubercles. Flagellum has 3 articles.

Maxilliped. As described for *St. maculosus* (Green, 1961, p. 278).

Pereion. Posterior angles of 1st-3rd epimera bluntly rounded, those of 4th epimera right-angled and rounded; 5th-7th epimera produced backwards and progressively more acute. Dorsal surface of pereion smooth, bearing many scattered, long setae; in dorsal view of animal these setae project beyond outline of body (fig. 15). Tergites covered with pointed, simple scales.

Seventh pereiopod. No sexual differentiation. Ischion with sternal border straight; no setose tubercle on propodos.

Pleon. Abruptly narrower than pereion. Third to 5th pleura small, acute. Telson trapezoidal with posterior angles rounded. Dorsal surface of pleon smooth, without long setae except for two which project beyond posterior border of telson.

First pleopod (fig. 17). Exopodite subtriangular, with outer border moderately indented, apex rounded and crenate. Endopodite subcylindrical, tapering; its terminal flagelliform process ends in a simple point, without setae.

Second pleopod (figs 18, 19). Length of articles of endopodite: 1st 0.10 mm., 2nd 0.27 mm. Second article styliform, almost uniform in width until near apex; apical point blunt and bent outwards. On dorsal surface an oblique groove, with strongly chitinized walls, extends throughout length of article; near base of article its inner wall is corrugated. Middle third of groove ornamented with many small, backwardly-directed bars of chitin.

Fifth pleopod. Exopodite not pigmented. Groove for endopodite of 2nd pleopod occupies about half length of exopodite.

Uropod. Length of articles: protopodite 0.11 mm., exopodite 0.17 mm., endopodite 0.14 mm.

Female

Size. Largest specimen: length 2.3 mm., breadth 1.0 mm.

Female differs from male in the following structures:

First to 3rd pereiopods, 1st pleopod. (As described for *St. maculosus*).

Second pleopod (fig. 20). Endopodite conical and elongated, its distal two-thirds bearing comb-setae. Length of exopodite approximately three-fifths that of endopodite; length (along inner border): exopodite 0.13 mm., endopodite 0.20 mm.

Fifth pleopod. Exopodite without groove.

Habitat

Type locality. Description is based on specimens obtained from debris in forest, dominated by eucalypts but with the inclusion of some myrtle (southern beech), on Mt Wellington, Tasmania.

Type specimens have been selected from examples

Figs 10-13.—*Styloniscus phormianus* (Chilton).

Fig. 10.—Right 1st-3rd epimera, dorsal view, showing setae.
Fig. 11.—Distal part of right 1st pleopod of male, dorsal view.
Fig. 12.—Left 2nd pleopod of male, dorsal view.
Fig. 13.—Left 2nd pleopod of female, dorsal view.

Figs 14-20.—*Styloniscus hirsutus,* n.sp.

Fig. 14.—Left 2nd antenna, ventral view.
Fig. 15.—Right 1st-3rd epimera, dorsal view, showing setae.
Fig. 16.—Distal part of left 1st pereiopod of male, anterior view, showing hyaline scales on meros and carpos.
Fig. 17.—Distal part of right 1st pleopod of male, dorsal view.
Fig. 18.—Left 2nd pleopod of male, dorsal view.
Fig. 19.—Second article of endopodite of left 2nd pleopod of male, dorsal view.
Fig. 20.—Left 2nd pleopod of female, dorsal view.

found beside Shoobridge Track (altitude 580 m.), on 26.VI.1957, 2 males and 18 females (3 ovigerous), and on 24.X.1963, 8 males and 2 females. Paratype slides have been prepared from these collections and from one made by Professor V. V. Hickman at Fern Tree (altitude 430 m.), on 28.IX.1957, 7 males and 4 females.

Other localities. Specimens of comparable size were found in debris in a myrtle (southern beech) forest near Collinsvale.

Larger specimens were obtained from debris in a forest of eucalypts and tree ferns at Tarraleah (altitude 610 m.), on 7.X.1957, 15 males and 19 females; collectors were Professor V. V. Hickman, Dr J. L. Hickman and the author.

Large form of St. hirsutus

Specimens from Tarraleah, Tasmania.

Size. Largest male: length 4.8 mm., breadth 2.4 mm. Largest female: length 7.2 mm., breadth 3.6 mm.

These large specimens, which previously (Green, 1961, p. 274) were assigned to *St. phormianus*, have been re-examined and their general agreement with the smaller isopods from Mt Wellington and Collinsvale has been confirmed. In particular, both forms possess many long setae on cephalon and pereion and their 2nd male pleopods are the same. Thus the larger isopods from Tarraleah are now assigned to *St. hirsutus*.

Apart from size, specimens from Tarraleah differ from those found on Mt Wellington as follows:

Flagellum of 2nd antenna with 5-7 articles. No brushes of hyaline scales on 1st-3rd pereiopods of some males. Exopodite of 1st male pleopod with outer border more deeply indented. Some specimens are more extensively pigmented, thus pigment present in exopodite of 5th pleopod.

Remarks

On the basis of a comparison with published descriptions, the Tasmanian isopods now named as *St. hirsutus* previously (Green, 1961) were identified as *St. phormianus* (Chilton). Following the examination of specimens of *St. phormianus* from New Zealand, this identification has been reconsidered. A detailed comparison has been made between type material of *St. hirsutus* from Mt Wellington, Tasmania, and examples of *St. phormianus* collected in Dunedin, New Zealand. Differences are listed in Table 3.

When specimens from New Zealand and Tasmania are placed side by side, it is evident that two groups are represented. However the differences between them are not great and most of these are relative rather than absolute. Also the large isopods from Tarraleah, Tasmania, tend towards *St. phormianus* in some of the features which differ between the smaller forms of the two groups (e.g. hyaline scales of 1st-3rd pereiopods of male, exopodite of 1st male pleopod). However, irrespective of their size, the New Zealand and Tasmanian isopods can be distinguished from each other by the relative length and number of setae on cephalon and pereion and by small but constant differences in the 2nd male pleopod.

There is no doubt that the setose styloniscids found in Tasmania are distinct from *St. phormianus* found in New Zealand. However it is not easy to judge, on present knowledge, whether the first group should be separated at the specific level or regarded as a subspecies of *St. phormianus*. A final assessment would depend on whether or not intermediate forms occur elsewhere. On the evidence of the material now in hand the Tasmanian isopods are ranked as a new species, *St. hirsutus*, closely related to *St. phormianus*.

TABLE 3.

St. phormianus (Chilton)	*St. hirsutus*, n.sp.
Locality: Dunedin, N.Z.	Locality: Mt Wellington, Tasmania.
Largest specimens: male: length 3.3 mm., breadth 1.6 mm. female: length 4.9 mm., breadth 2.3 mm.	Largest specimens: male: length 2.0 mm., breadth: 0.8 mm. female: length 2.3 mm., breadth 1.0 mm.
Setae on cephalon and pereion longer and less numerous (fig. 10).	Setae on cephalon and pereion shorter and more numerous (fig. 15).
Flagellum of 2nd antenna with 3-5 articles.	Flagellum of 2nd antenna with 3 articles.
No brushes of hyaline scales on meros and carpos of 1st-3rd pereiopods of male.	Brushes of hyaline scales on under surface of meros and carpos of 1st-3rd pereiopods of male (fig. 16).
Exopodite of 1st male pleopod with outer border deeply indented, apex almost acute (fig. 11).	Exopodite of 1st male pleopod with outer border less deeply indented, apex less sharply rounded (fig. 17).
Second article of endopodite of 2nd male pleopod: with apical point broader, scarcely demarcated from rest of article; groove with thicker walls, a few chitinous bars near base of groove (fig. 12).	Second article of endopodite of 2nd male pleopod: with apical point narrower, more distinct from rest of article; groove with thinner walls, many chitinous bars throughout middle third of groove (figs 18, 19).

STYLONISCUS PLANUS, n.sp.
(Figs 21-28)

Location of type specimens

Holotype male and allotype female in the Australian Museum, Sydney.

Paratype male and female in the Western Australian Museum, Perth.

Paratype male and female in the Tasmanian Museum, Hobart.

Male

Size. Largest specimen: length 8.2 mm., breadth 4.1 mm.

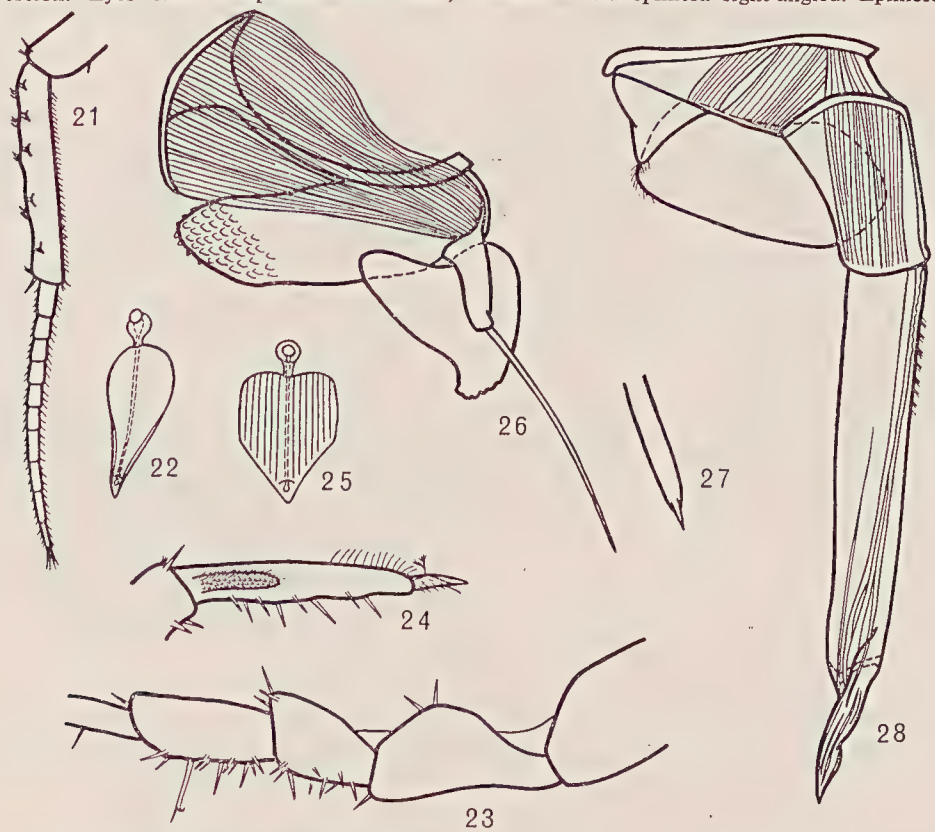
Colour. Dorsal surface of live animal dark purplish-brown, mottled with unpigmented patches. Large patches, one at base of each of 1st-6th epimera, together form a row on each side. Exopodites of pleopods pigmented. In some specimens, dark brown colour is partly replaced by orange-brown, especially on epimera.

Cephalon. Surface of vertex smooth; scale-setae like those on pereion. Eyes each composed of 3 ocelli, separated from one another and arranged in a triangle; the two lateral ocelli set on a slight swelling at side of cephalon.

Second antenna (fig. 21). Length of peduncle 2.76 mm., length of flagellum 1.09 mm. On outer surface of 5th article of peduncle are two rows of tubercles, 4 or 5 in each row; each tubercle bears a group of hyaline scales. Flagellum has 10 articles. In smaller specimens (body length less than 7 mm.), number of articles in flagellum ranges from 9 to 6.

Maxilliped. Ischion distinct. Remainder of endopodite divided on inner side into 4 lobes, with divisions between proximal three lobes extended as 2 faint, oblique suture lines across ventral surface. Lobes bear setae of different thicknesses; comb-setae present on inner border, below lobed part. On outer border are 3 long setae and a pencil of setae. Endite subcyclindrical and setose, terminating in a conical, setose process, below which are 3 spines.

Pereion. Posterior angles of 1st epimera rounded, those of 2nd epimera right-angled. Epimera of 3rd-7th



Figs 21-28.—*Styloniscus planus*, n.sp.

Fig. 21.—Fifth article of peduncle and flagellum of right 2nd antenna, ventral view.
Fig. 22.—Scale-seta on 1st tergite of pereion, dorsal view.
Fig. 23.—Carpos, meros and ischion of right 7th pereiopod of male, anterior view.
Fig. 24.—Propodos and dactylos of right 7th pereiopod of male, posterior view.
Fig. 25.—Scale-seta on posterior border of telson, dorsal view.
Fig. 26.—Left 1st pleopod of male, dorsal view.
Fig. 27.—Apex of endopodite of left 1st pleopod of male, dorsal view.
Fig. 28.—Left 2nd pleopod of male, dorsal view.

segments produced backwards and progessively more acute. Second to 7th epimera delimited by faint coxal suture lines, more noticeable on 5th-7th than on 2nd-4th segments. Dorsal surface of pereion smooth. Scale-setae on pereion (fig. 22) each have scale part triangular, sharply pointed at apex, not striated. Tergites covered with simple, non-striated scales.

Seventh pereiopod. Ischion (fig. 23) has sternal border shallowly incurved; lower part of ischion prolonged distally below meros. On posterior surface of propodos (fig. 24) is an elongated tubercle, covered partly by setae and partly by scales.

Pleon. Abruptly narrower than pereion. Third to 5th pleura small, acute. Telson trapezoidal with posterior border straight; two large scale-setae (fig. 25), each with broad, subtriangular, striated scale part, project beyond posterior border. Dorsal surface of pleon smooth.

First pleopod (fig. 26). Exopodite subtriangular with apex sharply rounded and crenate; outer border deeply indented near apex. Endopodite subcylindrical, terminating in a long, flagelliform process which bears no setae; at its end, process narrows abruptly to form a distinct apical point (fig. 27).

Second pleopod (fig. 28). Length of articles of endopodite : 1st 0.42 mm., 2nd 1.35 mm. Second article styliform, with apex acute. At about one-quarter of its length from apex, an oblique band of chitin crosses ventral surface of article; length from band to apex (along inner border) 0.36 mm. Breadth of 2nd article decreases only slightly in proximal three-quarters; at level of chitinous band there is sudden decrease in breadth due to incurvature of both sides. On dorsal surface, an oblique groove extends for full length of article, twisting onto outer side in distal quarter; near base of article inner wall of groove is corrugated. Setae present on inner surface of 2nd article, near its base. Dorsal surface of apical region of article ornamented with longitudinal ridges of chitin.

Fifth pleopod. Groove for endopodite of 2nd pleopod extends through most of length of exopodite; region occupied by groove more darkly pigmented than remainder.

Uropod. Length of articles: protopodite 0.60 mm., exopodite 1.40 mm., endopodite 0.86 mm.

Female

Size. Largest specimen : length 9.5 mm., breadth 4.6 mm.

Female differs from male in the following structures:

First to 3rd pereiopods, 1st pleopod. (As described for *St. maculosus).*

Seventh pereiopod. Ischion has sternal border straight; distal border of lower part of ischion slopes back towards basis. No tubercle on propodos.

Second pleopod. Endopodite styliform, its distal two-thirds bearing comb-setae. Length of exopodite about two-thirds that of endopodite; length (along inner border): exopodite 0.63 mm., endopodite 0.97 mm.

Fifth pleopod. Exopodite without groove or its associated band of darker pigment.

Habitat

Type locality. Description is based on specimens found on austral-montane moorland (altitude 1,070 m.), on Wombat Moor, Mt Field National Park, Tasmania. Collections made were as follows: under pieces of earth on the exposed floor of an empty pond, on 16.XII.1960, one male and two females, collected by Dr J. L. Hickman; under stones on damp ground, near patches of surface water, on 6.III.1962, 8 males and 9 females; under stones on damp ground, near a small temporary stream, on 10.X.1963, 3 males and 9 females.

Remarks

As indicated in Table 1, *St. planus* has most in common with *St. magellanicus* Dana. A comparison of the characters of *St. planus* with accounts of *St. magellanicus* given by Dana (1853, p. 736), Vandel (1952, p. 18; 1963, p. 67) and Andersson (1960, p. 548) has revealed few significant differences between the two. The differences are listed in Table 4. Of these distinctions, the most importance is attached to the last; such subdivision of the second article of the endopodite of the 2nd male pleopod has been used by Andersson (1960, p. 547) in separating material of *St. magellanicus, St. pallidus* and *St. simrothi.*

Consideration was given to establishing the new Tasmanian form as a subspecies of *St. magellanicus,* as the two forms appear to be closely related. However, in view of past experience in equating Tasmanian and New Zealand species on the evidence of published descriptions, only to find it necessary to create new species after a comparison of actual material, it seemed wiser to give specific rank to *St. planus* also. Certainly it is simpler to synonymize two species, if a closer relationship is shown to exist, than it is to subdivide one species which later proves to be heterogeneous.

TABLE 4.

St. magellanicus Dana	*St. planus,* n.sp.
Spiniform scale-setae present on vertex; scale-setae of pereion with apices blunt; no striated scale-setae described from telson.	No spiniform scale-setae found on vertex; scale-setae of pereion with apices acute (fig. 22); striated scale-setae present on telson (fig. 25).
Outer lobe of 1st maxilla with 9 teeth and 2 other processes.	Outer lobe of 1st maxilla with 11 teeth and 2 other processes.
Second article of endopodite of 2nd male pleopod crossed by a chitinous band at about half length of article from apex.	Second article of endopodite of 2nd male pleopod crossed by a chitinous band at about one-quarter length of article from apex (fig. 28).

STYLONISCUS OTAKENSIS (Chilton)
(Figs 29-34)

Philougria rosea Chilton, 1883, p. 73 (in part)
—— *non* Koch, 1835-44.

Philygria rosea Thomson and Chilton, 1886, p. 157 (in part).

Trichoniscus otakensis Chilton, 1901, p. 117.

Styloniscus otakensis Vandel, 1952, p. 42.

Descriptions by Chilton and Vandel

In his account of *Trichoniscus otakensis,* Chilton (1901, p. 117) did not describe or figure those appendages which are sexually differentiated. Instead he claimed that none of the legs of the male is specially modified and that the legs and pleopods (including those pleopods modified in the male) closely resemble those of *Tr. phormianus.* Chilton did not specify a type locality for *Tr. otakensis* but stated that this species is 'widely distributed throughout the South Island, N.Z., in damp situations'.

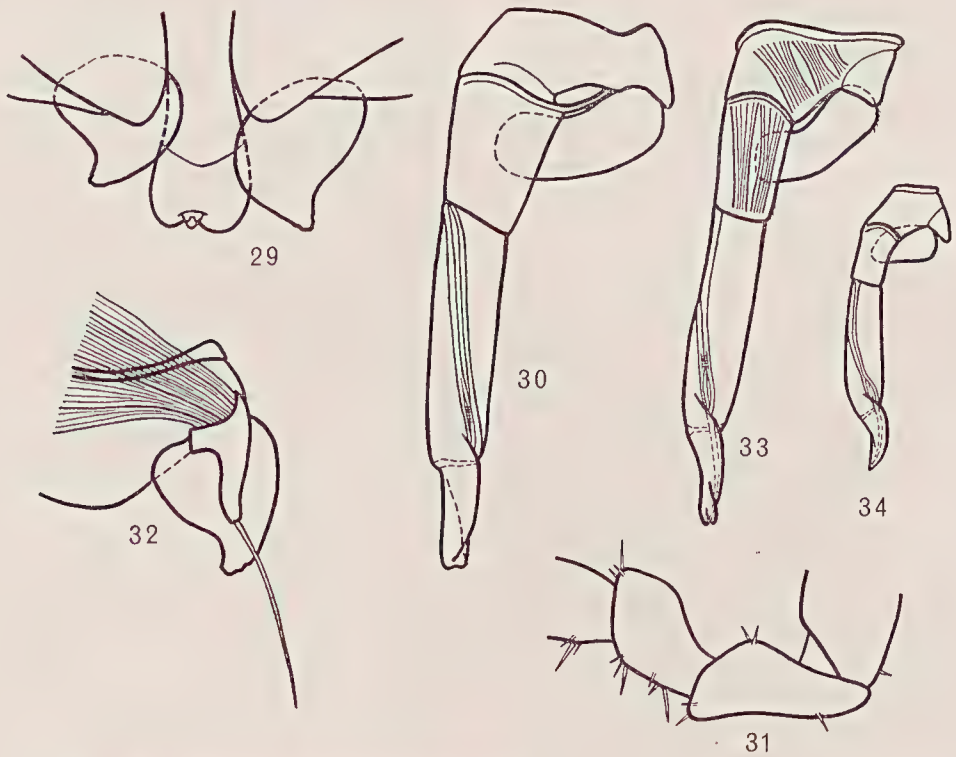
Vandel's (1952, p. 42) account of *Styloniscus otakensis* was based on two specimens, male and female, from Omaio (Bay of Plenty), on the east coast of the North Island of New Zealand. Vandel contradicted Chilton's claim that the pleopods of *St. otakensis* closely resemble those of *St. phormianus.* He presented for *St. otakensis* descriptions and figures of structures not dealt with by Chilton.

Variation in Styloniscus otakensis

Examples of a species of *Styloniscus* collected in the Town Belt, Dunedin, N.Z. (South Island) have been identified as *St. otakensis.* These specimens agree with the descriptions given by Chilton (1901) and Vandel (1952) in most characters. However they differ from Vandel's example from Omaio in some features of the 1st and 2nd pleopods of the male, these appendages being closer in appearance to the corresponding pleopods of *St. phormianus.*

Slides of *Trichoniscus otakensis* from Chilton's collection, now lodged in the Canterbury Museum, Christchurch, N.Z., have therefore been examined. Details of these slides are as follows:

Dunedin, N.Z. (no date); 2 slides: male pereiopods; male pleopods.



Figs 29-34.—*Styloniscus otakensis* (Chilton).
Fig. 29.—Male organ and 1st pleopods of male (endopodites missing), overlapped by parts of 7th sternite, ventral view (Chilton's slide, Dunedin).
Fig. 30.—Right 2nd pleopod of male, dorsal view (Chilton's slide, Dunedin).
Fig. 31.—Meros and ischion of right 7th pereiopod of male, anterior view (Dunedin).
Fig. 32.—Distal part of left 1st pleopod of male, dorsal view (Dunedin).
Fig. 33.—Right 2nd pleopod of male, dorsal view (Dunedin).
Fig. 34.—Right 2nd pleopod of male, dorsal view (Auckland).

Flagstaff Hill, 30.XI.1887; 3 slides: female pereiopods; pleon of female; young specimen from brood sac.

Mihiwaka, 26.V.1890; 2 slides: appendages of female; whole mount.
(Flagstaff Hill and Mihiwaka are near Dunedin).

On the slide of male pleopods, from Dunedin, the endopodites of the 1st pleopods are missing and some details of the 2nd pleopods are obscured by dark staining; otherwise there is close agreement between the 1st and 2nd male pleopods on Chilton's slide (figs 29, 30) and those of the author's specimens from Dunedin (figs 32, 33).

Differences between examples of *St. otakensis* from Dunedin and Omaio are given in Table 5.

Strouhal (1961, p. 201), describing his new subspecies, *St. otakensis fernandezianus* from Juan Fernandez, noted differences in the 1st and 2nd male pleopods which are related to the size of the animal. In the exopodite of the 1st pleopod, the outer border is more deeply indented in juvenile males (2.3 - 3.0 mm. long) than it is in adult males (3.8 - 4.4 mm. long). In the second article of the endopodite of the 2nd pleopod, the narrower apical part is shorter, relative to the wider basal part, in juvenile males than it is in adult males.

Although it is doubtful whether Strouhal's subspecies, *fernandezianus*, should be attributed to *St. otakensis*, as was pointed out by Vandel (1963, p. 72), the possibility that a similar variation with age may occur in New Zealand examples of *St. otakensis* should be considered. However the evidence available at present does not support such an explanation for the differences listed in Table 5. The animals compared are of similar size; Vandel's male specimen from Omaio was 3 mm. long, the largest males in the author's collection from Dunedin are 2.8 mm. long. Also there is agreement in the characters of the 1st and 2nd male pleopods of specimens from Dunedin obtained in different seasons (30.VII.1964 and 12.XII.1966).

There is, however, further evidence for variation among examples of *St. otakensis* from different localities. Two males and five females collected from manuka litter near Auckland, N.Z. (North Island) in 1965, by Mr E. Scott, have been assigned to *St. otakensis*. These specimens agree with Chilton's (1901) and Vandel's (1952) descriptions in most characters of the species. The larger of the two males (2.0 mm. long) has been dissected. Its 1st pleopod agrees with that of *St. otakensis* from Dunedin. In the endopodite of the 2nd pleopod, length of 2nd article is almost four times length of 1st article; lengths: 1st 0.067 mm., 2nd 0.25 mm. Also the apical part of the 2nd article is subacute, though not as finely tapered as that of the specimen from Omaio. Thus the 2nd pleopod of a male specimen from Auckland (fig. 34), although basically similar to that of males from Dunedin, shows differences which tend towards those exhibited by the male specimen from Omaio (see Table 5).

Typical form of Styloniscus otakensis

Evidently there exists in New Zealand a kind of *Styloniscus* which possesses most of the characters attributed to *St. otakensis*, e.g. spinose tubercles on cephalon, pereion and pleon, but which shows geographical variation in features of the 1st and 2nd pleopods of the male. The material available at present is quite inadequate as a basis for any decision on the relationships of these variants to each other. However, in any future study of variation in *St. otakensis* the form from the South Island, studied by Chilton, should be regarded as the typical form of the species against which all deviations are compared.

Supplement to Chilton's (1901) description

In the following account, descriptions of the 1st male pleopod (exopodite), 2nd and 5th male pleopods are based on Chilton's slide from Dunedin, with which the author's specimens agree. The remainder is based on the author's specimens from Dunedin. (No appendage on Chilton's slide of male pereiopods is recognizable as a 7th leg; i.e. none has the characteristic fringe of long scales on upper surface of propodos. Also no 2nd female pleopod is mounted separately on Chilton's slides).

Size. Largest male specimen: length 2.8 mm., breadth 1.0 mm. Largest female specimen: length 4.2 mm., breadth 1.8 mm.

Seventh male pereiopod. Ischion (fig. 31) with sternal border shallowly incurved; lower part of ischion prolonged distally below meros. Propodos has a scale-covered tubercle on posterior surface.

First male pleopod (figs 29, 32). Exopodite subtriangular with apex sharply rounded and crenate, outer border deeply indented near apex. Endopodite subcylindrical, terminating in a long, flagelliform process, apex of which is simply pointed and apparently without setae.

Second male pleopod (figs 30, 33). Exopodite subrectangular, much shorter than 1st article of endopodite. Length of exopodite: Chilton's slide 0.09 mm.; author's slide 0.065 mm. Endopodite with 2nd article about three times as long as 1st article. Length of articles: Chilton's slide, 1st 0.18 mm., 2nd 0.55 mm.; author's slide, 1st 0.14 mm., 2nd 0.43 mm. Second article styliform, decreasing in width only slightly for almost three-quarters of its length, then width decreases abruptly to form a narrower, apical part. Length of apical part: Chilton's slide 0.15 mm.; author's slide 0.125 mm. At level of change in width is a band of chitin across ventral surface. On dorsal surface an oblique groove extends down full length of 2nd article; near middle of groove are a few fine bars of chitin. In apical part, groove is overlapped by an outwardly-directed fold. Apex of endopodite blunt and bilobed.

Fifth male pleopod. Groove for endopodite of 2nd pleopod occupies most of length of exopodite.

Second female pleopod. Endopodite styliform, its distal two-thirds with comb-setae. Length of exopodite less than half that of endopodite; length (along inner border): exopodite 0.20 mm., endopodite 0.46 mm.

Habitat

Specimens were obtained from debris in a mixed forest in the Town Belt, Dunedin, N.Z. (altitude 90 m.). Collections were made on 30.VII.1964, 6 males and 21 females, and on 12.XII.1966, 9 males and 34 females.

Female specimens were found in forest debris at Papatowai, South Otago, and near Tuatapere, Southland, (both in the South Island).

TABLE 5. *ST. OTAKENSIS* (Chilton)

	Dunedin (South Island)	Omaio (North Island)
1st pleopod of male	Exopodite with outer border indented.	Exopodite with outer border not indented.
	Flagelliform process of endopodite simply pointed at apex, apparently without setae.	Flagelliform process of endopodite with a pencil of setae at apex.
2nd pleopod of male	Length of 2nd article of endopodite three times length of 1st article.	Length of 2nd article of endopodite seven times length of 1st article.
	Second article of endopodite with its apex blunt and bilobed.	Second article of endopodite with its apex sharply pointed.

STYLONISCUS NICHOLLSI Vandel

Styloniscus nicholllsi Vandel, 1952, p. 30.

Seventh pereiopod. Vandel (1952, p. 35) stated that the 7th pereiopod in *St. nichollsi* is without sexual differentiation. When the species was recorded again (Green, 1961, p. 275), no cause for amendment was observed. However, a re-examination of specimens collected near Shoobridge Track on Mt Wellington, Tasmania, on 26.VI.1957, has shown that sexual differentiation is present. The 7th pereiopod of the male has an oval tubercle, covered partly by setae and partly by scales, situated on the posterior surface of the propodos; no such tubercle is present in the female. There is no differentiation of the ischion of the 7th pereiopod; in both sexes its sternal border is straight.

Presence in caves

Examples of *St. nichollsi* have been found in caves at Hastings, in the south, and at Mole Creek and Loongana in the north-west of Tasmania. These isopods usually were associated with dead wood or with debris near underground streams. Information on collections is given in Table 6.

A comparison of specimens obtained from King George V Cave, Hastings, with the epigean specimens of *St. nichollsi* found on Mt Wellington has shown that the isopods in these two samples are alike morphologically.

Pigmentation. All of the specimens examined have been stored in 80% alcohol, but the initial method of preservation was not uniform. In the isopods found in caves at Hastings and Mole Creek the body pigment is normal in distribution, but is a lighter brown in colour than that of the epigean examples from Mt Wellington; the dark brown coloration of the latter is matched only by the specimen from Loongana. The eyes of the cave-dwellers are normal, each being composed of three black ocelli.

There is no previous record of Styloniscidae from caves in Tasmania. However a comparable situation exists in New Zealand where May (1963, p. 185) has recorded the presence in caves of *St. phormianus* (Chilton), another species which normally lives above ground.

TABLE 6. *ST. NICHOLLSI* IN CAVES

Locality	Cave	Specimens	Date	Collectors
Hastings	King George V Cave	5♂, 6♀	21.IV.1968	Mr & Mrs A. Goede
„	„	2♂, 2♀	23.VI.1968	„
Mole Creek	Georgie's Hall	1♂, 1♀	6.III.1967	Mr R. J. Cockerill
„	„	2♀	27.I.1968	„
„	Scott's Cave	2♂, 2♀	6.IV.1968	Mr & Mrs A. Goede
„	„	1♂	10.VI.1968	Mr R. J. Cockerill
„	Baldock's Cave	3♀	7.IV.1968	Mr & Mrs A. Goede
„	Herbert's Pot	1♀	6.VII.1968	Mr A. Goede
„	Mersey Hill Cave	2♀	7.VII.1968	„
Loongana	Old Tourist Cave	1♂	22.II.1969	Mr & Mrs A. Goede

GENUS *NOTONISCUS* Chilton

Notoniscus Chilton, 1915, p. 418.
Notoniscus Chilton, *nom emend.* Green, 1961, p. 284.

For synonymy and generic diagnosis, see Green (1961, p. 284).

Genus *Notoniscus* contains the following species: *N. helmsii* (Chilton, 1901); *N. australis* (Chilton, 1909); *N. tasmanicus* (Chilton, 1915); *N. fernandezi, N. secundus, N. tertius,* all Strouhal, 1961; *N. chiltoni,* n.sp.

Key to species of *Notoniscus* represented in Tasmania

Tubercles on pereion forming 4 rows in male, 5 rows in female; 3rd pleura small compared with 4th and 5th pleura —— —— —— —— —— —— —— —— *chiltoni.*
Tubercles on pereion forming 6 rows in both sexes; 3rd pleura as large as 4th and 5th pleura — *tasmanicus.*

NOTONISCUS AUSTRALIS (Chilton)
(Figs 35, 36)

Haplophthalmus australis Chilton, 1909, p. 662.
Notoniscus australis Chilton, 1915, p. 421.

Chilton's material

Chilton's collection of *Notoniscus australis,* lodged in the Canterbury Museum, Christchurch, N.Z., comprises female specimens obtained on Campbell Island, south of New Zealand, in November, 1907. The following material has been examined by the author:

Two specimens in spirit, designated as type specimens.

Three slides, labelled 'co-type', bearing one stained specimen and separate appendages.

One dried specimen, mounted on a slide.

(Further information is given in Table 7).

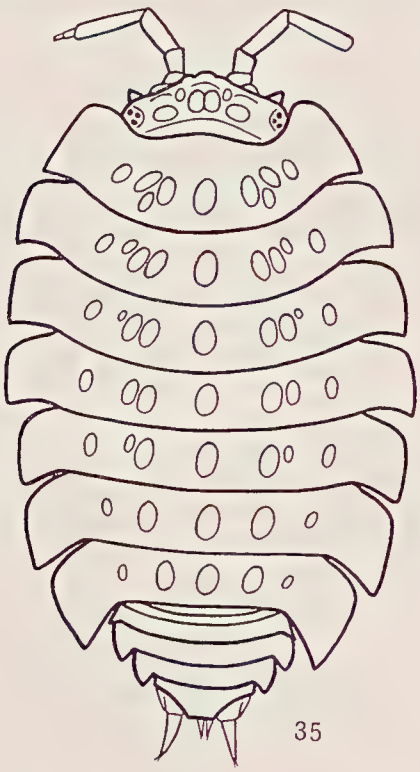
NOTONISCUS CHILTONI, n.sp.
(Fig. 37)

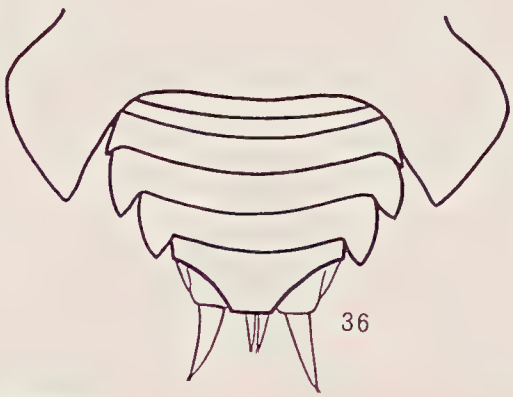
Notoniscus australis Green, 1961, p. 287.
—— *non* (Chilton, 1909).

Location of type specimens

Holotype male and allotype female in the Australian Museum, Sydney.

Paratype male and female in the Western Australian Museum, Perth.





Figs 35-36.—*Notoniscus australis* (Chilton).
Fig. 35.—Female specimen, dorsal view (small, scattered tubercles of pereion omitted; 2nd antennae incomplete). Length of specimen: 4.5 mm.
Fig. 36.—Seventh segment of pereion (tubercles omitted), pleon and uropods, dorsal view.

Fig. 37.—*Notoniscus chiltoni,* n.sp.
Fig. 37.—Seventh segment of pereion (tubercles omitted), pleon and uropods, dorsal view.

Paratype male and female in the Tasmanian Museum, Hobart.

Description

The account given by Green, 1961, pp. 287-9, figs 52-56.

Type locality

In debris in a myrtle (southern beech) forest near Collinsvale, Tasmania (altitude 730 m.). Type material was collected on 12.VI.1957 and 19.VI.1957.

Remarks

A form of *Notoniscus* found near Collinsvale, Tasmania, was identified as *N. australis* (Chilton) following a comparison with Chilton's (1909, 1915) descriptions of his specimens from Campbell Island.

A subsequent opportunity to examine the type material of *N. australis,* lodged in the Canterbury Museum, Christchurch, N.Z., has shown that the Tasmanian form is distinct from Chilton's species.

The Tasmanian specimens previously named as *N. australis* differ from all other established species of *Notoniscus* (and of the allied genus, *Paranotoniscus* Barnard) in the pattern of tubercles on the pereion, while additional differences, concerning the ornamentation of the pleon or the shape of the pleura, occur in some cases (see Barnard, 1932, p. 202; Chilton, 1915, p. 418; Green, 1961, p. 286; Strouhal, 1961, p. 205). Thus this Tasmanian form represents a new species for which the name of *Notoniscus chiltoni,* in honour of the late Professor C. Chilton, is proposed.

Differences between Chilton's female type material of *N. australis* from Campbell Island and female type specimens of *N. chiltoni* from Collinsvale, Tasmania, are given in Table 7. (Males of *N. australis* have not been recorded). Although the basic pattern of ornamentation in female specimens of *N. australis* and *N. chiltoni* is the same (i.e. 5 longitudinal rows of tubercles on pereion), there are differences in the details of this pattern and these are supported by differences in the pleura and uropods.

TABLE 7.

N. australis (Chilton)	*N. chiltoni,* n.sp.
Large tubercles on each segment of pereion together form 5 longitudinal rows; on 1st-5th segments the intermediate (2nd and 4th) positions are each occupied by 2 or 3 tubercles set close together, instead of by a single tubercle as occurs elsewhere in the rows (fig. 35); small tubercles scattered on dorsal surface between the 5 rows.	Large tubercles on each segment of pereion together form 5 longitudinal rows; all of these tubercles occur singly; no small tubercles on dorsal surface between the 5 rows (Green, 1961, fig. 56). (Male of *N. chiltoni* has 4 rows of tubercles on pereion).
Fourth and 5th pleura of pleon ovoid, with both lateral borders convex (fig. 36).	Fourth and 5th pleura of pleon semicrescentic, with outer border convex, inner border slightly concave (fig. 37).
Uropod with rami longer than protopodite; length of articles: protopodite 0.42 mm., exopodite 0.59 mm., endopodite 0.62 mm.	Uropod with rami shorter than protopodite; length of articles: protopodite 0.27 mm., exopodite 0.21 mm., endopodite 0.25 mm.

NOTONISCUS TASMANICUS (Chilton)

Haplophthalmus tasmanicus Chilton, 1915, p. 424.
Chiltonia tasmanica Arcangeli, 1923, p. 314.
Chiltonella tasmanica Vandel, 1952, p. 96.
Notoniscus tasmanicus Green, 1961, p. 289.

Holotype

Chilton's (1915, p. 424) description of *Haplophthalmus tasmanicus* was based on a single specimen, collected at 'Fern Tree Gully, Hobart, Tasmania'. Presumably the locality referred to is Fern Tree on the lower slopes of Mt Wellington (altitude 430 m.). This holotype is lodged in the Canterbury Museum, Christchurch, N.Z., and has been examined by the author.

Supplementary type specimens

Additional reference specimens of *Notoniscus tasmanicus* have been selected from a collection made on 12.VI.1957 and 19.VI.1957, from debris in a myrtle (southern beech) forest near Collinsvale, Tasmania (altitude 730 m.)., about 12 Km. north-west of Fern Tree.

One male and one female specimen have been lodged in each of the following institutions:

The Australian Museum, Sydney.

The Western Australian Museum, Perth.

The Tasmanian Museum, Hobart.

These examples have been designated as plesiotypes, being part of a collection on which a subsequent description (Green, 1961, p. 289) was based.

CONCLUSION

The Tasmanian species, *Styloniscus sylvestris, St. hirsutus, Notoniscus chiltoni* and *N. tasmanicus* all inhabit litter on the ground in damp forests. *St. nichollsi* is also present in such forests, but it has been found in other situations as well, e.g. this is the only species of Styloniscidae yet recorded from caves in Tasmania. The author's specimens of *St. thomsoni, St. phormianus* and *St. otakensis,* collected in New Zealand, came from the same kind of habitat, i.e. damp forest litter, as did *St. sylvestris* and *St. hirsutus* in Tasmania.

St. planus has been found only on austral-montane moorland, at an altitude of 1,070 m., in Mt Field National Park, Tasmania. *St. sylvestris* occurs at comparable altitudes, at 1,130 m. on Mt Wellington and at 1,030 m. near Lake Dobson in Mt Field National Park, but it has been collected there from litter under trees and shrubs, not from treeless moorland. The more exposed habitat of *St. planus,* compared with that of other styloniscids in Tasmania, is of interest in view of the far southern distribution of its counterpart, *St. magellanicus.* The latter is a native of southern Chile, Patagonia and Tierra del Fuego; it has also been recorded, by Chilton (1909, p. 661), from the Auckland Islands and Campbell Island, south of New Zealand.

With the establishment of new species for the Tasmanian forms previously placed in *St. thomsoni, St. phormianus* and *N. australis,* no species of Styloniscidae is now thought to be common to Tasmania and New Zealand. The earlier assignment of specimens of *N. chiltoni* to *N. australis* was a simple case of mistaken identity; however closer relationships seem to exist between members of the other pairs.

St. thomsoni and *St. sylvestris* undoubtedly should be ranked as distinct species, yet they are more like each other than either is to any sympatric species (e.g. there are similar features in their 1st and 2nd male pleopods). *St. phormianus* and *St. hirsutus* are even more alike; both have long setae on the cephalon and pereion, and a 2nd male pleopod with the endopodite almost uniform in width, also both species include an atypical, larger form. *St. magellanicus* and *St. planus* seem to represent another pair of closely-related species. A wider knowledge of the variation and distribution of these isopods is needed before their true relationships can be determined.

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REFERENCES

Andersson, A. (1960): South American terrestrial isopods in the collection of the Swedish State Museum of Natural History. *Ark. Zool.*(2), **12,** 537-70.

Barnard, K. H. (1932): Contributions to the crustacean fauna of South Africa. No. 11. Terrestrial Isopoda. *Ann.S.Afr.Mus.* **30,** 179-388.

Barnard, K. H. (1958): Terrestrial isopods and amphipods from Madagascar. *Mém.Inst.scient.Madagascar* (A) **12,** 67-111.

Barnard, K. H. (1965): Isopoda and Amphipoda collected by the Gough Island Scientific Survey. *Ann. S.Afr.Mus.* **48,** 195-210.

Chilton, C. (1886): A new species of *Philygria. Trans. N.Z. Inst.* **18,** 159-61.

Chilton, C. (1901): The terrestrial Isopoda of New Zealand. *Trans.Linn.Soc.Lond.(Zool.)* **8,** 99-152.

Chilton, C. (1909): The Crustacea of the subantarctic islands of New Zealand. In *'The Subantarctic Islands of New Zealand'.* Vol. 2, 601-71. (Wellington).

Chilton, C. (1915): Some terrestrial Isopoda from New Zealand and Tasmania, with description of a new genus. *J.Linn.Soc.(Zool.)* **32,** 417-27.

Dana, J. D. (1853): Crustacea. In *'United States Exploring Expedition. . . . under the command of Charles Wilkes, U.S.N.'* Vol. 13, pt. 2, 691-1618. (Philadelphia). (Folio Atlas of 96 plates published in 1855).

Green, A. J. A. (1961): A study of Tasmanian Oniscoidea (Crustacea : Isopoda). *Aust.J.Zool.* **9,** 258-365.

May, B. M. (1963): New Zealand cave fauna. II. The limestone caves between Port Waikato and Piopio districts. *Trans.R.Soc.N.Z.(Zool.)* **3,** 181-204.

Strouhal, H. (1961): Die Oniscoideen-Fauna der Juan Fernández-Inseln (Crustacea, Isopoda terrestria). *Annln.naturhist.Mus.Wien* **64,** 185-244.

Vandel, A. (1952): Les Trichoniscides (Crustacés, Isopodes) de l'hémisphère austral, leur place systématique, leur intérêt biogéographique. *Mém.Mus.natn.Hist.nat.Paris* (A) **6,** 1-116.

Vandel, A. (1963): Isopodes terrestres recueillis en Amérique du Sud par Claude Delamare Deboutteville. In: Delamare Deboutteville, C. et Rapoport, E. *'Biologie de l'Amérique australe.'* Vol. **2,** 63-100. (Cent.natn.Rech.scient., Paris).

Verhoeff, K. W. (1939): Von Dr G. H. Schwabe in Chile gesammelte Isopoda terrestria, Diplopoda und Chilopoda. *Arch.Naturgesch.* (N.S.) **8,** 301-24.

Verhoeff, K. W. (1951): Landisopoden aus Süd-Amerika. *Further Zool. Res. Swed. Antarct. Exp., Stockholm,* Vol. 4, pt **5,** 1-19.

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THREE TASMANIAN SPIDERS OF THE GENUS *CELAENIA* THORELL (ARANEIDA) WITH NOTES ON THEIR BIOLOGY

By
V. V. Hickman
(With one plate and nine text figures)

ABSTRACT

Specimens of the Bird-dung Spider, *Celaenia excavata* (L. Koch) from Tasmania have been identified by Dr H. W. Levi as synonymous with *Celaenia kinbergi* Thorell. An amplified description of the dwarf male of this spider is given with some observations on the biology of the species. Thirteen egg-sacs made by one female contained a total of 1630 eggs. Of these 724 gave rise to males, 718 to females and 188 failed to develop. The sex ratio is therefore almost 1 : 1. From hatching of the egg males pass through three instars, females through seven, before becoming adult. In the case of specimens hatched in October males reach maturity in about 134 days and females in 395 days. Under laboratory conditions males, after reaching maturity, may live from 255 to 615 days, females for about 425 days.

Celaenia distincta (O. Pick-Cambr.) from New South Wales and *Celaenia atkinsoni* (O. Pick-Cambr.) from New Zealand are recorded from Tasmania for the first time. The hitherto unknown male of *C. distincta* is described and notes on the biology of the two species given.

INTRODUCTION

Spiders belonging to the genus *Celaenia* Thorell occur in Australia and New Zealand. Bonnet (1956) lists five species from each country. It is probable, however, that when the species are fully compared the number may be reduced by synonymy. Female specimens of one and the same species often appear very different according as to whether they are gravid or non-gravid. When the abdomen is distended with eggs, tubercles and folds on the surface tend to become smoothed out. Of the species listed only one is recorded as occurring in Tasmania (Simon 1892). In the present paper two others are reported from this State.

Males of species in the genus *Celaenia* are dwarfs and rarely seen. Most of the descriptions are based on females. By raising specimens in the laboratory the males of two species were bred from the egg to maturity.

Celaenia kingbergi Thorell 1868
(Pl. I, fig. 1)

The spider which occurs in Tasmania and other parts of Australia and is often referred to as the Bird-dung Spider, Orchard Spider or Death's Head Spider, has long been identified as *Celaenia excavata* (L. Koch). However, Dr H. W. Levi, who examined specimens which I sent him from Tasmania and also the type of *C. kinbergi* Thorell, states *(in litt.)* that the two species are synonymous. The name *C. kinbergi* takes priority over *C. excavata.*

The female has been fully described by Thorell (1868), Koch (1872) and others. The description of the male as given by Karsch (1878) is very brief. Hence the following more detailed account is provided.

MALE: Measurements in millimetres:

Body length	2.97
Length of carapace	1.48
Width of carapace	1.37
Length of abdomen	2.00
Width of abdomen	2.57
Height of abdomen	2.00

Leg	*Femur*	*Patella*	*Tibia*	*Metatarsus*	*Tarsus*	*Total*
1	1.94	0.79	1.09	0.60	0.45	4.87
2	2.12	0.75	1.07	0.62	0.44	5.00
3	1.04	0.45	0.51	0.49	0.34	2.83
4	1.16	0.41	0.62	0.55	0.34	3.08
Palp	0.38	0.19	0.16	—	0.62	1.35

Colour: Carapace dark brown with a yellowish V-shaped mark pointing forwards on the highest part of the thoracic region and two yellow radial marks on each side. Margin yellowish. Three black submarginal spots on each side. A median yellow stripe extending downwards beween AME to front margin. Palpi, chelicerae, maxillae and labium dark brown. Sternum dark brown with an elongate median yellow mark on posterior half. Legs with coxae and distal half of femora dark brown. Basal half of femora almost white. Patellae light brown. Tibiae white with black band round basal half. Metatarsi white with black band at apex. Tarsi mainly white basally and black distally. Abdomen white with a black median spot in front and several black marks on each side. Spinnerets black, surrounded by a large black area.

Carapace: Almost as wide as long, rounded at the sides, moderately high between second and third legs, sloping steeply to hind margin. Head region strongly narrowed forming a blunt point, which projects over the clypeus. A median row of black clavate setae extends from eyes to middle of carapace. Similar setae are present on front and sides of head region and also in radial rows on sides of thorax.

Eyes: Eight in two rows. Viewed from above front row appears recurved and hind row slightly procurved. Eye ratio AME : ALE : PME : PLE = 6 : 5 : 6 : 5. AME separated from each other by 5/2 and from ALE by 3/2 of their diameter. PME separated from each other by 5/2 and from PLE by 3/2 of their diameter. Median ocular quadrangle almost square. Lateral eyes contiguous. Height of clypeus equal to twice the diameter of AME.

Chelicerae: Conical, slightly geniculate, sloping backward, with two small teeth on retromargin of furrow.

Fang slightly curved and coarsely serrate on basal half of inner margin.

Maxillae: Slightly converging, rounded in front and on outer side. A light scopula on inner margin and a well devolped serrula in front.

Labium: Wider than long, rounded in front reaching about half the length of the maxillae.

Sternum: Shield-shape, longer than wide in ratio 3 : 2, widest between second coxae, slightly procurved on front margin and ending in a narrow point between fourth coxae, slightly excavated round bases of third and fourth coxae.

Legs: Length order 2. 1. 4. 3. Lightly clothed with barbed hairs Patellae and basal half of tibiae with thick clavate hairs (fig. 1) on dorsal surface. Femora of first, second and third pairs of legs with two longitudinal rows of short stout spines on ventral surface. Spines of row nearer promargin somewhat larger than those of other row. Patellae of first and second legs strongly bent near base. Six trichobothria on basal half of each tibia and one on each metatarsus except the fourth, which has none. Three tarsal claws. Upper claws of first and second legs strongly dissimilar, the proclaw being much smaller than the retroclaw, which is long and only slightly curved (fig. 2). The proclaw has three teeth, the retroclaw two, the second tooth from base being in the form of an oval blade (fig. 3). Lower claw bent almost at a right angle, sharply pointed, with one tooth. The upper claws of third and fourth legs more nearly similar. Several accessory claws present on all tarsi.

Palpi: Nearly equal in length to carapace, lightly clothed with barbed hairs. Cymbium large and spoon-shaped with a short, stout curved apophysis at the base on the retrolateral side. The form of the genital bulb partly extended is shown in fig. 4. Embolus is of the coniform type. Middle division of genital bulb has a hook-shaped median apophysis. Tibia has six trichobothria, three on each side.

Abdomen: Wider than long, with height equal to length. Overlaps carapace anteriorly. Highest part in front half. Anterior surface steeply ascending and marked with a large trapezium-shaped depression. On each side of the highest part are two small tubercles. Posterior surface slopes steeply to hind margin. At sides the integument forms a series of about five folds, which become continuous above the spinnerets. There is a transverse row of four muscle spots on the highest part of the abdomen and two similar rows, one below the other on the posterior surface. The integument is tough with patches of black clavate hairs. Ventral surface somewhat folded. Spinnerets six, conical, anterior pair larger than others.

Occurrence: Males like the females are usually found on shrubs and small trees, where they rest on the leaves. Occasionally they occur on grass. Specimens have been collected at Launceston, 21 March 1925; Sandy Bay, 23 February 1944; and New Town, 25 February 1946.

BIOLOGY

Habits: The female has been found on apple trees, gorse, briars, pines, cypresses, prickly box and other shrubs and trees. It generally rests on a small mat of threads on the surface of a leaf, but when the egg-sacs are made, it is usually found resting on them and is rarely more than three metres from the ground, often less than two metres. The spider does not spin a web for the capture of prey. Its food appears to consist entirely of night-flying moths. Specimens bred to maturity in the laboratory refused at all stages to feed on flies. Even the young spiders, newly emerged from the egg-sac, would accept only small moths. During the day the spider sits motionless with its legs folded close to the body. It makes no attempt to capture prey and, if touched, shows little tendency to move. At night, however, it often rests with the first and second pairs of legs extended or with the legs in the same attitude it may hang suspended on a thread. If a moth flutters near enough, it is at once seized and held securely against the rows of spines below the femora.

Egg-sacs: In one season a single female may make as many as 13 egg-sacs but the usual number seems to be about seven (Butler 1933, Roberts 1937). The egg-sacs are spherical and 9 - 15 mm. in diameter (Table I). The external wall is brown with a few dark streaks and is tough and parchment-like. Immediately within the outer wall is a soft fluffy layer of yellowish silk that surrounds the egg-mass. A female specimen of the spider found in a garden at New Town, 24 October 1950, had seven egg-sacs, all woven into a cluster with strong threads of brownish silk. The spider and its egg-sacs were transferred to a vivarium in the laboratory, where a further six egg-sacs were made during the next four months. The laying of eggs and making of the egg-sac is carried out at night and occupies about one hour. When the eggs are laid they adhere together in a mass, which is suspended by a thread. The spider hangs by one of its second legs from a foot-hold on the shrub or on previously made egg-sacs. It then brings its spinnerets against the suspended egg-mass and proceeds to cover it with the layer of soft yellowish silk. To accomplish this the mass is rotated and manipulated by means of the spider's palpi and free legs. Finally the outer layer of brown parchment-like material is added. The completed egg-sac is then drawn up and attached to the shrub or to the other egg-sacs.

In the thirteen egg-sacs made by the one spider the number of eggs in the separate sacs varied from 32 to 235. Egg-sacs of the same size did not always contain the same number of eggs (Table I).

Table I

Celaenia kinbergi Thorell. Progeny from thirteen egg-sacs (A-M) made by the same spider.

Egg-Sac	Diameter (mm.)	Eggs	Males	Females	Undeveloped
A	15.0	235	99	119	17
B	14.0	166	89	76	1
C	14.0	216	110	101	5
D	13.0	145	67	68	10
E	13.0	176	89	87	0
F	13.0	136	49	58	29
G	12.0	112	45	33	34
H	12.0	75	33	41	1
I	12.0	145	39	39	67
J	11.0	64	31	33	0
K	11.0	56	27	29	0
L	11.0	72	39	31	2
M	9.0	32	7	3	22
Totals	—	1630	724	718	188

Immature stages and number of instars: The eggs are yellow and vary in shape, some being spherical with a diameter of 1.43 mm., others oval with a length of 1.63 mm. and a width of 1.41 mm. The duration of incubation varies according to the temperature. In summer eggs usually hatch in about 28 days. The chorion splits about 10 - 13 days prior to hatching. An ecdysis takes place within the chorion at the time of hatching. The exuviae are left behind in the crumpled chorion, when the first instar escapes into the egg-sac. The exuviae thus cast off bear the two egg-teeth and the integument of the two book-lungs, each with nine leaves.

The *first instar* corresponds to that designated by Holm (1940) as the first postembryonal stage. It has the following measurements in millimetres:

Total length	2.06
Length of carapace	0.80
Width of carapace	0.74
Length of abdomen	1.37
Width of abdomen	1.31

Leg	*Femur*	*Patella*	*Tibia*	*Metatarsus*	*Tarsus*	*Total*
1	0.61	0.42	0.34	0.25	0.27	1.89
2	0.56	0.37	0.34	0.26	0.27	1.80
3	0.41	0.26	0.25	0.21	0.26	1.39
4	0.41	0.26	0.29	0.25	0.23	1.44
Palp	0.16	0.14	0.14	—	0.21	0.65

The body is colourless except for the yellow egg-yolk within the abdomen. Integument of body and appendages is covered with numerous minute spinules. Carapace rounded in front and slightly narrowed. Eyes becoming pigmented. Chelicerae without teeth; the fang short and conical. Legs and palpi without hairs and bristles, except for a few on each side of the tarsi, one above each metatarsus and two above each tibia (fig. 5). Trichobothria absent. Tarsal claw single and without teeth. Abdomen broadly oval, without tubercles and hairs. Six spinnerets present but non-functional. Book-lungs have 13 leaves.

In the case of eggs that hatch in October the duration of the first instar is 23-25 days (Table II). However, the progeny from eggs laid in the late summer or autumn may remain as first or second instars throughout the winter and not emerge from the egg-sacs until the spring or early summer.

The *second instar* corresponds to that designated by Holm (1940) as the second postembryonal stage. It has the following measurements in mm.:

Total length	2.23
Length of carapace	0.97
Width of carapace	0.91
Length of abdomen	1.26
Width of abdomen	1.54

Leg	*Femur*	*Patella*	*Tibia*	*Metatarsus*	*Tarsus*	*Total*
1	1.10	0.55	0.59	0.33	0.33	2.90
2	1.03	0.47	0.59	0.34	0.34	2.77
3	0.63	0.30	0.34	0.26	0.29	1.82
4	0.71	0.31	0.40	0.33	0.29	2.04
Palp	0.15	0.12	0.16	—	0.24	0.67

Colour and markings as in the adult. The general form of the body also resembles that of the adult. The carapace, however, is not so strongly narrowed in front and the tubercles on the head region of the mature female are not present. On the distal half of the dorsal surface of the second femora there is a dense clothing of thick black barbed hairs. Two trichobothria on each tibia and one on each metatarsus except the last, which has none. Tarsal claws as in adult. Tarsus of palpi in males is already swollen and it is therefore possible to distinguish the sexes at this early stage. Form of abdomen like that of adult but surface is more rounded. Spinnerets are now functional and the spider able to spin a drag line.

Table II

Celaenia kinbergi Thorell. Number and duration (in days) of the juvenile instars of six specimens (A-F) bred in the laboratory.

	Chorion split	Hatched	Instars I	II	III	IV	V	VI	VII	Total	Sex
A	20.9.1949	30.9.1949	23	137	181	31	46	38	—	456	♀
B	20.9.1949	1.10.1949	23	100	23	21	43	155	30	395	♀
C	20.9.1949	3.10.1949	24	83	27	—	—	—	—	134	♂
D	20.9.1949	2.10.1949	25	79	31	—	—	—	—	135	♂
E	20.9.1949	2.10.1949	25	104	27	—	—	—	—	156	♂
F	20.9.1949	2.10.1949	25	79	29	—	—	—	—	133	♂

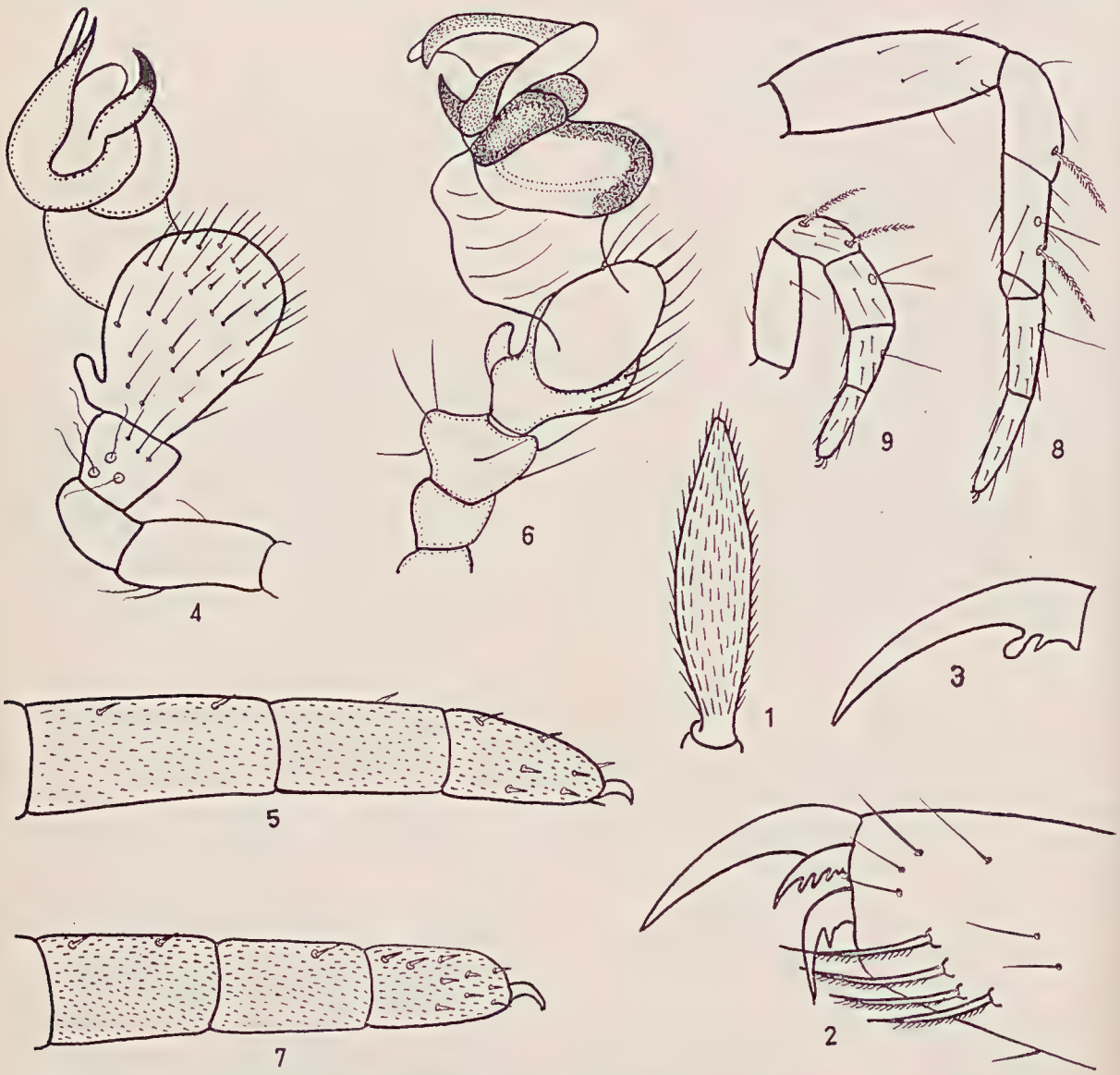
In summer the second instar remains in the egg-sac for about seven days. It then bites a hole in the tough outer wall and emerges. In specimens bred in the laboratory in October the duration of the second instar varied from 79 to 137 days (Table II). In the colder months of the year the duration is much longer and may last through the winter. The young in the same egg-sac do not all develop at the same rate. In an egg-sac collected in the field on 15 April 1969 the young were in the first instar. Some reached the second instar on 29 May 1969, but others did not do so until 30 June 1969, a difference of 32 days in the rate of development.

In the case of males the total number of juvenile instars passed through after hatching is three; in the case of females it is seven (Table II). One female specimen (A in Table II) reached the sixth instar but died before becoming mature.

From five egg-sacs made in the period 21 November 1950 to 30 January 1951, young, in the second instar, emerged after 57, 52, 49, 51 and 55 days respectively from the date when the egg-sac was made.

Sex-ratio: The 13 egg-sacs (Table I) made by the female collected on 24 October 1950 contained a total of 1630 eggs. Of these 188 failed to develop. The remaining 1442 gave rise to 724 males and 718 females, a sex-ratio of almost 1 : 1.

Longevity: The life-span under natural conditions is unknown. In the laboratory four males bred from eggs collected in the field lived, after becoming adult, for 250, 255, 564 and 619 days respectively. A female likewise bred in the laboratory lived for 426 days.



Figs. 1-5.—*Celaenia kinbergi* Thorell. 1, clavate hair. 2, claws of first leg. 3, retroclaw of first leg. 4, palpus of male with bulb extended. 5, three distal segments of front leg of first instar.
Figs. 6-7.—*Celaenia distincta* (O. Pick-Cambr.) 6, palpus of male with bulb extended. 7, three distal segments of front leg of first instar.
Figs. 8-9.—*Celaenia atkinsoni* (O. Pick-Cambr.). 8, second leg of second instar. 9, third leg of second instar.

Celaenia distincta (O. Pick-Cambr., 1869)
(Pl. 1, fig. 2)

According to Rainbow (1902) the single specimen on which Pickard-Cambridge based his description was an old and dry example labelled as coming from 'New Holland' and deposited in the Hope Collection, University Museum, Oxford. Over the past 100 years only one other specimen has been recorded. This is a female from Prospect, N.S.W. and is described by Rainbow (1902).

The spider occurs in Tasmania. A female with egg-sacs was found on the Domain, Hobart 15 January 1968, and another, also with egg-sacs, on 5 December 1968. A male, hitherto unknown, was bred from the eggs and is described hereunder.

MALE: Measurements in millimetres:

Body length	2.46
Length of carapace	1.14
Width of carapace	0.97
Length of abdomen	1.54
Width of abdomen	1.83
Height of abdomen	1.71

Leg	*Femur*	*Patella*	*Tibia*	*Metatarsus*	*Tarsus*	*Total*
1	1.38	0.63	0.73	0.40	0.27	3.41
2	1.38	0.59	0.77	0.42	0.31	3.47
3	0.68	0.30	0.38	0.30	0.27	1.93
4	0.73	0.31	0.52	0.38	0.25	2.19
Palp	0.22	0.16	0.14	—	0.36	0.88

Colour: Carapace dark brown with a wide median-Y-shaped yellowish band, the arms of the band extending one on each side of the head region. Ocular area and clypeus dull yellow. Eyes surrounded by black rims. Behind eyes a pair of triangular brown spots separated by a narrow median line. Two yellow radial stripes on each side of thoracic region. Margin yellow. Chelicerae, maxillae and labium brown. Sternum yellow with dark brown margin. Femora, patellae and basal half of tibiae dark brown above and on the sides, lighter below. Distal half of tibiae almost white. Metatarsi and tarsi light brown. Abdomen dull white above. Anterior surface with a dark median V-shaped mark, on each side of which the surface is brown with vertical rows of dark spots. A large dark area on each side of posterior half. Ventral surface dull white with light brown marks. Spinnerets light brown.

Carapace: Strongly narrowed in front. Ocular area projecting over clypeus. Eight eyes in two rows. Viewed from above front row appears strongly recurved, hind row slightly recurved. Ratio of eyes AME : ALE : PME : PLE = 6 : 5 : 6 : 5. AME separated from each other by twice their diameter and from ALE by 3/2 of their diameter. PME separated from each other by 5/3 and from PLE by 3/2 of their diameter. Median ocular quadrangle almost square. Lateral eyes contiguous. Three setae in a transverse row between AME and PME. Height of clypeus equal to once diameter of AME.

Chelicerae: Inclined slightly backward, conical, two teeth on retromargin of furrow, no scopula, fang curved and strongly serrate on basal half of inner margin.

Maxillae: Slightly converging with serrula on front margin and a light scopula on inner side. Outer side rounded.

Labium: Rounded in front, twice as wide as long, reaching about half the length of maxillae.

Sternum: Shield shape, longer than wide in ratio 9 : 8, truncate in front and ending in a blunt point between fourth coxae, margin slightly excavated round bases of second, third and fourth coxae, lightly clothed with barbed setae.

Legs: Length order 2.1.4.3. Lightly clothed with barbed hairs. First and second legs almost equal in length. Femora of first three pairs with two longitudinal rows of short stout spines on ventral surface. The spines in the row nearer the promargin larger than those in other row. On the distal two thirds of the dorsal surface of first and second femora there are small tooth-like spines at the base of the barbed setae. Patellae of first and second legs bent at right angles near base. A single trichobothrium on each metatarsus except the fourth, which has none, and six on the basal half of each tibia. The upper tarsal claws of first and second legs dissimilar, the proclaw being small with four teeth, the retroclaw large with two teeth near base. Lower claw strongly bent, with two teeth. Upper claws of third and fourth legs more nearly similar.

Palpi: Cymbium spoon-shaped with a small curved apophysis at the base on retrolateral side. In the specimen under examination the genital bulb is fully extended. The basal haematodocha is very large. There is a curved sharp median apophysis and the embolus is of the coniform type. (fig. 6). The tibia has six trichobothria, three on each side. The cymbium is lightly clothed with hairs.

Abdomen: Wider and higher than long, the highest part being in the anterior half. It rises steeply from front margin, which partly overlaps the carapace. The highest part forms a transverse rectangle, the hind margin of which is recurved. On each anterior corner of the rectangle are two large black clavate hairs and on each posterior corner a small conical tubercle directed backwards. The central area of the rectangle is depressed and has a pair of dark muscle spots. The posterior half of the dorsal surface slopes steeply to the hind margin and is marked with two pairs of muscle spots. At the sides the integument forms a series of folds, which become continuous above the spinnerets. The folds carry a number of black clavate hairs. The six spinnerets are conical, the anterior pair larger than the others.

BIOLOGY

Habits: As in the case of the preceding species the spider makes no web for the capture of prey. Its food consists entirely of night-flying moths. The two female specimens collected were found resting on their egg-sacs, which were attached to the dead branches of a prickly box tree.

Egg-sacs: A group of six egg-sacs was found 15 January 1968, and a group of three 5 December 1968, each about two metres above the ground. The sac is spherical and about 6.0 mm. in diameter. As the sacs are made the spider binds them into a close cluster and covers them with the scales and other remnants from the moths on which it has fed (Pl. fig. 2). The outer wall of the egg-sac is brown and paper-like. Within the wall is a layer of soft yellowish silk cover-

ing the egg-mass. Eggs or young from five separate sacs numbered 22, 29, 31, 33 and 42 respectively. Although the egg-sacs are brown, the silk threads binding them together and the moth scales covering them give them a grey appearance, which resembles that of the twigs and branches to which they are attached.

Immature stages and number of instars: The eggs are yellow and about 0.86 mm. in diameter. Since the egg-sacs were found in the field and not made under laboratory conditions, the duration of incubation and of the separate instars is not known accurately. From the three egg-sacs collected 5 December 1968, young in the second instar emerged on 15th, 16th, and 29th January 1969, respectively.

As in the other species an ecdysis takes place before or at the time of hatching and the exuviae are left behind in the crumpled chorion after the escape of the first instar.

The *first instar* has the following measurements in millimetres:

Body length	1.37
Length of carapace	0.63
Width of carapace	0.57
Length of abdomen	0.91
Width of abdomen	0.80

Leg	*Femur*	*Patella*	*Tibia*	*Metatarsus*	*Tarsus*	*Total*
1	0.42	0.22	0.24	0.16	0.19	1.23
2	0.42	0.25	0.23	0.16	0.19	1.25
3	0.22	0.16	0.19	0.16	0.19	0.92
4	0.26	0.20	0.23	0.15	0.19	1.03
Palp	0.14	0.10	0.11	—	0.16	0.51

Pale yellow in colour. Carapace not strongly narrowed in front. Chelicerae without teeth, fang short and conical. Integument of body and appendages covered with numerous minute spinules. Hairs and bristles absent, except for two short setae above each tibia, one above each metatarsus and several on each side of tarsi (fig. 7). Tarsal claw single and without teeth. Trichobothria absent. Abdomen broadly rounded, without tubercles and not elevated. Spinnerets present but not functional.

The *second instar* has the following measurements in millimetres:

Body length	1.43
Length of carapace	0.74
Width of carapace	0.74
Length of abdomen	0.86
Width of abdomen	0.86
Height of abdomen	0.86

Leg	*Femur*	*Patella*	*Tibia*	*Metatarsus*	*Tarsus*	*Total*
1	1.30	0.60	0.68	0.34	0.27	3.19
2	1.30	0.56	0.67	0.41	0.27	3.21
3	0.64	0.34	0.34	0.29	0.25	1.86
4	0.71	0.33	0.48	0.37	0.25	2.14
Palp	0.23	0.14	0.19	—	0.26	0.82

The second instar resembles the adult in coloration and general form. However, the carapace is not so strongly narrowed in front. On the tibia the legs have only two and the palpi only one trichobothrium. In the female two short conical tubercles represent the long tapering processes on the abdomen of the adult. At this stage there is little difference in the appearance of the sexes, except that the males already have enlarged palpi. The two pairs of large black clavate setae on the highest part of the abdomen in the adult male are present in both sexes of the second instar. Spinnerets are now functional and the young spiders able to spin their drag lines.

From a number of second instar specimens that emerged from an egg-sac on 15 January 1969, ten were isolated in small separate vivaria and maintained in the laboratory. Unfortunately all except two males died before reaching maturity. One of the males underwent ecdysis and became adult on 4 May 1969, the other on 7 May 1969. They lived until 3 December 1969, and died through the vivaria becoming overheated in sunshine.

Sex-ratio: In one egg-sac collected 15 January 1968 there were 23 males and 19 females, in another 20 males and 13 females. These numbers are too small to give a true indication of the sex ratio.

Celaenia atkinsoni (O. Pick-Cambr. 1879)
(Pl. I, figs 3 and 4)

The description of the female given by Pickard-Cambridge is adequate for the identification of the species. The spider is recorded from New Zealand and is now also reported from Tasmania.

All efforts to raise specimens to maturity in the laboratory failed and the male is still unknown.

BIOLOGY

Habits: The spider occurs on small shrubs and trees and usually about two metres from the ground. It does not make a web for the capture of prey but spins a few threads amongst leaves and twigs of the shrub for the attachment of its egg-sacs. It rests on a nearby leaf. During daytime the spider has its legs closely folded against the body, but at night it extends the first and second pairs ready to capture its prey, which consists entirely of small moths.

Egg-sacs: A female with six egg-sacs was found among the leaves at the top of some raspberry canes in a garden at New Town, 26 March 1969. Another female, also with six egg-sacs, was discovered among the leaves and berries on a Cotoneaster tree 13 April 1969. The egg-sacs bear a remarkable resemblance to dead and withered seed capsules or flower heads. They are somewhat spherical and produced into a stalk on one side. The spherical part varies in diameter from 3.31 - 4.56 mm. and the stalk varies in length from 3.4 - 4.0 mm. The outer wall of the sac has a number of small projections round the circumference. It is composed of densely woven brown silk and is very tough. Within the outer wall is a layer of soft light coloured silk surrounding the egg-mass. Unlike the two preceding species *C. atkinsoni* does not bind the egg-sacs into a close cluster. but suspends them separately on threads woven amongst the leaves of the shrub (Pl. I, fig. 4).

Immature stages and number of instars: The eggs are yellow and somewhat oval in shape measuring 0.85 mm. long and 0.80 mm. wide. Since no egg-sacs were made under laboratory conditions, the duration of incubation could not be determined accurately. From field observations, however, it appears to be about 25 days in late summer.

From some of the egg-sacs found on 13 April 1969 the young had already emerged. In three, however, they had not escaped. In one of these the chorion of the eggs had just split, in the second the young had hatched and were in the first instar, and in the third they were in the second instar and ready to emerge from the egg-sac. As in the preceding species one ecdysis takes place either before or at the time of hatching. The exuviae are left behind in the chorion, when the first instar hatches from the egg.

The *first instar* has the following measurements in millimetres:

Body length	1.09
Length of carapace	0.55
Width of carapace	0.52
Length of abdomen	0.82
Width of abdomen	0.71

Leg	*Femur*	*Patella*	*Tibia*	*Metatarsus*	*Tarsus*	*Total*
1	0.27	0.16	0.16	0.15	0.18	0.92
2	0.25	0.16	0.15	0.15	0.18	0.89
3	0.20	0.14	0.12	0.12	0.18	0.76
4	0.22	0.15	0.16	0.14	0.18	0.85
Palp	0.11	0.08	0.08	—	0.14	0.41

Coloration yellowish white, translucent. Carapace rounded in front. Eyes becoming pigmented. Chelicerae without teeth and with short conical fang. Integument of body and appendages covered with minute spinules. Hairs, bristles and spine absent except for two short setae above each tibia, one above each metatarus and about nine on each tarsus. Trichobothria absent. Abdomen broadly ovoid. Spinnerets not functional.

The *second instar* has the following measurements in millimetres:

Body length	1.03
Length of carapace	0.57
Width of carapace	0.51
Length of abdomen	0.68
Width of abdomen	0.57

Leg	*Femur*	*Patella*	*Tibia*	*Metatarsus*	*Tarsus*	*Total*
1	0.52	0.21	0.29	0.22	0.22	1.46
2	0.47	0.23	0.27	0.21	0.24	1.42
3	0.32	0.18	0.16	0.16	0.22	1.04
4	0.37	0.19	0.20	0.19	0.19	1.14
Palp	0.10	0.07	0.12	—	0.18	0.47

Coloration yellowish brown on cephalothorax and appendages, darker brown on each side of carapace and round margin of sternum. Femora brown on distal half of dorsal surface. Tibia brown at apex; metatarsi brown at base. Tarsi mainly brown. Abdomen white above, brown below. Spinnerets brown.

There is a marked difference from adult female in body form. Carapace not strongly narrowed anteriorly, the ocular area occupying the full width of front. A very large black barbed seta between PME and a slightly larger one (almost half the length of the carapace) at the hind end of head region. A transverse row of four white barbed setae on posterior half of thoracic region. Chelicerae with well developed fang and two teeth on retromargin of furrow. Ventral surface of first, second and third femora without the two longitudinal rows of short spines present in adult. A single large black barbed seta at the apex of first and second patella and also at both base and apex of third and fourth patella. A similar large seta at apex of first and second tibia but none on third and fourth (figs 8 & 9). One trichobothrium on first and second tibia, two on third and fourth; also one on each metatarsus, except the fourth, which has none. Three tarsal claws, upper pair similar with about four teeth; lower claw strongly bent and with one tooth. Palpi with one trichobothrium on tibia and four teeth on tarsal claw. Abdomen somewhat cordiform and without the large lateral lobes of the adult female. A small tubercle on each side of dorsal anterior third. A transverse row of four large black setae in front of tubercles. The median pair of setae about one third the length of the abdomen. On posterior half of dorsal surface two pairs of smaller black setae. Rest of surface lightly clothed with white barbed setae. Spinnerets are now functional and the spiderling able to spin.

In the second instar the palpi of the males are not obviously different from those of the female. At this stage therefore it is not possible to distinguish the sexes by this character and thus determine the sex-ratio.

Seven specimens newly emerged from an egg-sac were placed in separate vivaria in the laboratory. However, all efforts to raise them to maturity failed. They died before reaching the next instar. The number and duration of the instars is therefore unknown.

Male and female specimens of *Celaenia kinbergi* Thorell and *C. distincta* (O. Pick-Cambr.) and a female of *C. atkinsoni* (O. Pick-Cambr.) together with the egg-sacs of the three species will be lodged in the Australian Museum.

REFERENCES

BONNET, P., 1956: *Bibliographia Araneorum*. Toulouse. **2** (2): 919-1925.

BUTLER, L. S. G., 1933: The common and conspicuous spiders of Melbourne. *Vict. Nat.* **49,** 271-92.

HOLM, A., 1940: Studien uber die Entwicklung und Entwicklungsbiologie der Spinnen. *Zool. Bidrag, Uppsala.* **19,** 1-214.

KARSCH, F., 1878: Exotischaraneologisches. *Zeits. gesam. Naturw.,* **51,** 323-33, 771-826.

KOCH, L., 1867: Beschreibungen neuer Arachniden und *Myriapoden. Verh. zool-bot Ges. Wien.* **17,** 173-250.

————, 1872: *Die Arachniden Australiens. Nürnberg.* 105-368.

PICKARD-CAMBRIDGE, O., 1869: Descriptions of a new genus and six new species of spiders. *Journ. Linn. Soc. Lond.* **10,** 264-76.

————, 1879: On some new and rare spiders from New Zealand, with characters of four new genera. *Proc. Zool. Soc. London,* 681-703.

RAINBOW, W. J., 1902: Descriptions of some new Araneidae of New South Wales. No. 10. *Proc. Linn. Soc. N.S.W.* **27,** 484-92.

ROBERTS, N. L., 1937: Some notes on the Bird-dung Spider *(Celaenia excavata). Proc. Roy. Zool. Soc. N.S.W.* 1936-1937. 3-7.

SIMON, E., *1892: Histoire Naturelle des Araignée. Paris.* **1,** 1-1084.

EXPLANATION OF PLATE 1

Fig. 1.—*Celaenia kinbergi* Thorell with egg-sacs.
Fig. 2.—*Celaenia distincta* (O. Pick-Cambr.) with egg-sacs.
Fig. 3—*Celaenia atkinsoni* (O. Pick-Cambr.) on a leaf.
Fig. 4.—*Celaenia atkinsoni* (O. Pick-Cambr.) with egg-sacs.

Papers and Proceedings of the Royal Society of Tasmania, Volume 105

AN ABRUPT UPPER MIDDLE CAMBRIAN FAUNAL CHANGE, CHRISTMAS HILLS, TASMANIA, AUSTRALIA

By

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and

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(with two text figures)

ABSTRACT

Sediments containing two almost entirely different Upper Middle Cambrian faunas are in direct contact near Christmas Hills, Tasmania. Two reasons are advanced in explanation for this faunal change, (a) that there is a disconformity at the position of the faunal change, or (b) that the younger fauna replaced the older fauna due to a change in environment.

INTRODUCTION

A Cambrian sedimentary succession of unknown thickness occurs in the Christmas Hills area of far north-western Tasmania (fig. 1). Much of this area is covered by thick vegetation and all the sediments are deeply weathered, with exposure being limited to occasional outcrops in stream beds and road cuttings. The most common lithologies are siltstones and tuffs (or reworked tuffs) with minor occurrences of sandstone, greywacke and conglomerate. The available dips and strikes indicate that the Cambrian rocks of this area are strongly folded in places, although in the section discussed below the sediments have shallow dips (fig. 1). The only measured section is about 160 metres thick, but the entire sequence is probably much thicker. Within this measured section, well preserved Upper Middle Cambrian fossils were discovered by Gulline (1959) in a road cutting about 2.4 km. south of the Christmas Hills Post Office. Other localities have since been found. Banks (1962, p. 134) noted a 1959 personal communication from Öpik in which Öpik identified some of the trilobites, and stated that these indicated an age in the Late Middle Cambrian *Lejopyge laevigata II* Zone of the Queensland Middle Cambrian as listed by Öpik (1960, fig. 14). However, no mention of two separate faunas is made in Banks (1962).

THE FAUNAS

There are two principal faunas at the locality 2.4 km. south of the Christmas Hills Post Office. The lower fauna contains great numbers of a species of a possible new genus cf. *Oidalagnostus,* and species of *Clavagnostus,* other agnostids, *Nepea,* and other polymerid trilobites including very rare examples of *Dorypyge.* Inarticulate brachiopods, hyolithids and rare hydroids are also present. The upper fauna includes species of *Centropleura, Amphoton,* and other polymerids, *Ptychagnostus (Goniagnostus), Ptychagnostus* cf. *aculeatus* (Angelin), *Diplagnostus, Hypagnostus* cf. *brevifrons* (Angelin) *Oidalagnostus* and other agnostids, inarticulate brachiopods, dendroids, hyolithids and sponge spicules. The hydroids and dendroids are being described by P. Quilty and the trilobites by J. Jago.

The lower fauna is contained within about 20 metres of well sorted, buff coloured, slightly micaceous siltstone, with the frequency of most fossil species increasing up the section. *Nepea* is not known from near the base of the succession. The basal part of the overlying fauna is found in a pale buff-coloured laminated siltstone which generally becomes harder and greyer up the succession. The fossil content decreases rapidly after the first two or three metres. The density of occurrence of fossils in the lower is generally greater than that of the upper fauna. However, the proportion of complete or partially complete trilobites in the upper fauna is much greater than in the lower fauna.

The two faunas are almost entirely different with only *Clavagnostus, Peronopsis,* and cf. *Oidalagnostus* being common genera. Only part of a single pygidium of *Clavagnostus* is known from the upper fauna and cf *Oidalagnostus* is also much rarer there than in the lower fauna. The species of *Clavagnostus* present in the upper fauna is different from that in the lower fauna. However, the same species of cf. *Oidalagnostus* occurs in both faunas. The species of *Peronopsis* in the upper fauna is probably the same as that in the lower fauna, but it is much rarer in the upper fauna than within the lower fauna.

The presence of *Centropleura, Ptychagnostus* cf. *aculeatus* and *Hypagnostus cf. brevifrons* in the upper fauna suggests that the age of this fauna is either that of the *Lejopyge laevigata II* Zone or the *L. laevigata I* Zone of Öpik (1961). The age of the lower fauna is not known precisely. Its general aspect indicates that it can only be a little older than the upper fauna and the presence of *Clavagnostus* suggests that the lower fauna is probably not older than the *L. laevigata I* Zone. One rather odd feature of the lower fauna is the absence of *Ptychagnostus,* a genus usually found in the Upper Middle Cambrian agnostid faunas.

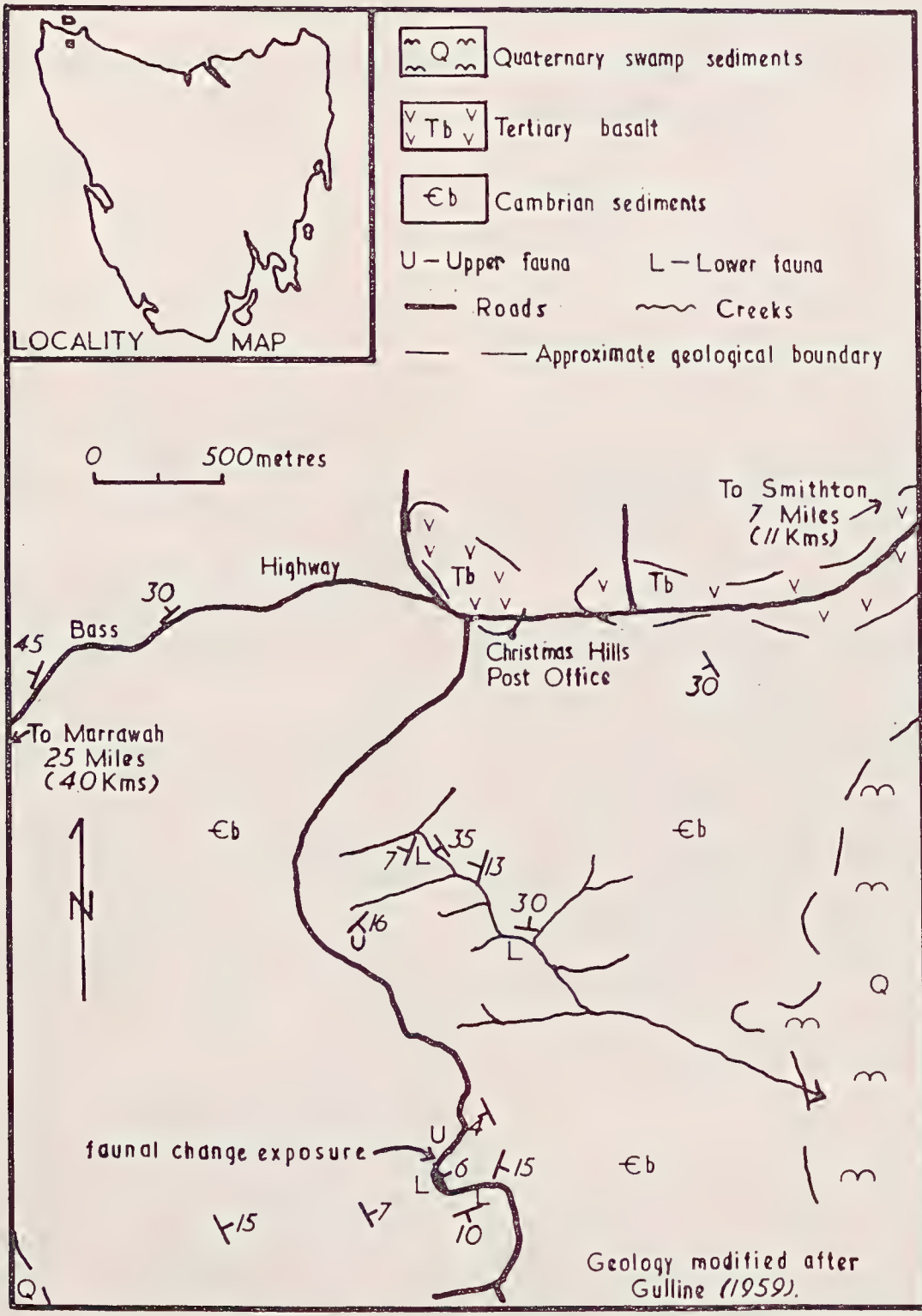

Fig. 1 — Geology of the Christmas Hills Area, Tasmania.

THE ABRUPT FAUNAL CHANGE

Prior to 1967 the boundary between the sediments containing the two faunas was unknown. In late December 1967 the authors dug out the boundary, with the results described below and summarized in fig. 2.

It was found that the faunal change is abrupt and that there are distinctly different siltstones on either side of the boundary. The uppermost 60 cm. of the lower fauna is contained within sediment that is much more weathered than the sediments above and below. The boundary between the sediments containing the two faunas occurs at the top of a 2.5 cm. band of ferruginous purple siltstone. Immediately above this purple siltstone is a 5 cm. layer of siltstone and ferruginous siltstone, which is overlain by well bedded pale siltstone containing the upper fauna. At this level the fauna includes *Hypagnostus* cf. *brevifrons* cf. *Oidalagnostus* and *Amphoton*. At the present the lowest known example of the upper fauna comes from about 9 cm. above the purple siltstone. The lowest *Centropleura* found to date is about 43 cm. above the boundary.

Immediately below the ferruginous purple siltstone is a 20 cm. thickness of clay and deeply weathered siltstone, which contains *Nepea* and other members of the lower fauna within 2 cm. of the purple siltstone. Beneath this is a slightly ferruginous siltstone 1-2 cm. thick underlain by 7.5 cm. of deeply weathered, whitish clay, which overlies 5 cm. of purple silt and ferruginous material. Below this are 19 cm. of deeply weathered siltstone and clay, which is underlain by well bedded siltstone, which contains abundant well preserved representatives of the lower fauna.

The above description indicates that there is a maximum of about 13 cm. between the lowest known member of the upper fauna and the highest known member of the lower fauna. With further collecting and excavation of the trench from which the above section was described this distance will probably decrease.

The marked change in faunas across the boundary, the different sediment types containing the faunas, and the highly weathered nature of these sediments may indicate a disconformity at this level. A second explanation for the abrupt faunal change is that there is no disconformity, but rather that the upper fauna represents an incoming fauna which displaced the original fauna due to a change in environment.

It is probable that the sediments containing the upper fauna were deposited in quieter waters than the sediments which contain the lower fauna. This is substantiated by the laminated nature of the sediments containing the upper fauna, and the greater proportion of complete trilobites in the upper fauna as compared to the lower fauna. The presence of sponge spicules and the preservation of dendroids in the upper fauna also implies quiet bottom conditions. The cause of this environmental difference is unknown, although it is possible that the upper fauna is a deeper water fauna than the lower fauna.

The lower fauna is seen at two other localities in the vicinity of Christmas Hills and the upper fauna is seen at one other place (see fig. 1). However, the nature of the outcrops at these localities does not allow the stratigraphic relationships between the sediments containing the two faunas to be determined. Thus at the present the faunal change can be inspected in the excavated section whose lateral extent is only about 60 cms. Until the field relationships are known in much more detail no firm explanation can be given.

ACKNOWLEDGEMENTS

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REFERENCES

Banks, M. R., 1962: Cambrian System in the Geology of Tasmania. *J. geol. Soc. Aust.*, *9(2)*, 127-45.

Gulline, A. B., 1959: The Underground Water Resources of the Smithton District. *Underg. Wat. Supply Pap., Tasm.*, **5**.

Öpik, A. A., 1960: Cambrian and Ordovician geology (of Queensland). *J. geol. Soc. Aust.*, **7**, 91-103.

————, 1961: Cambrian geology and palaeontology of the headwaters of the Burke River, Queensland. *Bur. Min. Resour. Bull.* **53**.

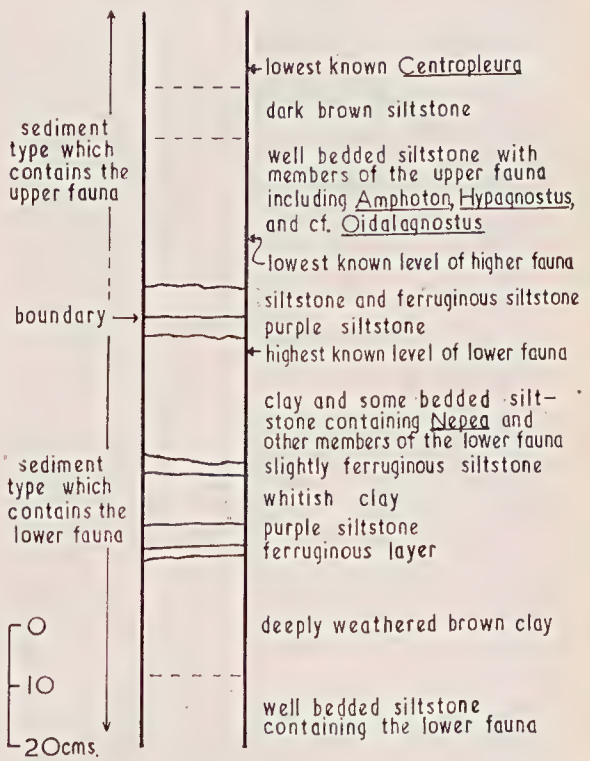
lowest known Centropleura
dark brown siltstone
sediment type which contains the upper fauna
well bedded siltstone with members of the upper fauna including Amphoton, Hypagnostus, and cf. Oidalagnostus
lowest known level of higher fauna
siltstone and ferruginous siltstone
boundary
purple siltstone
highest known level of lower fauna
clay and some bedded siltstone containing Nepea and other members of the lower fauna
sediment type which contains the lower fauna
slightly ferruginous siltstone
whitish clay
purple siltstone
ferruginous layer
deeply weathered brown clay
0
10
20cms.
well bedded siltstone containing the lower fauna

Fig.2——Section through the faunal change, Christmas Hills, Tasmania.

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HISTOLOGICAL AND HISTOCHEMICAL OBSERVATIONS OF THE CEPHALIC NEUROSECRETORY SYSTEM OF THE CRAB, *PARAGRAPSUS GAIMARDII* (H. MILNE EDWARDS)

By

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(With full plates of five text figures)

ABSTRACT

Anatomical, cytological and histochemical features of the neurosecretory system of the crab, *Paragrapsus gaimardii* are described. In the brain and the commissural ganglia, three types of neurosecretory cells are distinguished. The distribution of these cells in the brain and the commissural ganglia is described. In the eyestalk, four types of neurosecretory cells are identified and the distribution of these cells is described. The neurosecretory cells of the brain, the commissural ganglia, and of the eyestalks are all paraldehyde fuchsin — positive (PF-positive). Their tinctorial properties with the chrome-haematoxylin phloxine technique are described. The neurohaemal organ of the eyestalk, the sinus gland, is described both as regards its anatomical characters and its staining properties. The presence of allochthonous cells in the sinus gland is revealed. The allochthonous neuroglial cells of the sinus gland do not appear to be active gliosecretory cells. However, some of the neuroglial cells of the brain, especially those of the protocerebrum, do appear to be active gliosecretory cells. The neurosecretory material of the cephalic neurosecretory system of *P. gaimardii* is proteinaceous with disulphide groups being markedly present.

INTRODUCTION

The neurosecretory cells and organs of the eyestalk of crabs have attracted considerable attention from both histologists and physiologists. Studies of the structure and cytology of the neurosecretory system of the crab eyestalk have been made by Hanström (1937, 1947), Enami (1951), Bliss and Welsh (1952), Bliss, Durand and Welsh (1954), Potter (1954, 1958), Miyawaki (1956a, c, 1960), Matsumoto (1958), Valente (1959) and Szudardky (1963). Similarly, a number of studies have been made of the neurosecretory cells of the cerebral ganglion (Enami 1951, Bliss and Welsh 1952, Bliss, Durand and Welsh 1954, Parameswaran 1956, Inoue 1957, Matsumoto 1958, Miyawaki 1960, Szudardky 1963 and Baid, Hafidh and Dabagh 1967). Histochemical observations on the nature of the neurosecretory material in crabs have been made by Gabe (1952), Miyawaki (1956b, c, 1960) and Rehm (1959).

In view of the importance of neurosecretion in controlling many major aspects of the physiology of crabs and in view of the lack of clear correlations in the types of neurosecretory cell types so far described in various species of crabs, the cerebral and optic ganglia of *Paragrapsus gaimardii* were examined histologically as a preliminary step to further studies of the neurosecretory system.

MATERIALS AND METHODS

Mature male or female *P. gaimardii*, in the stage of Intermoult (C3-C4 of Drach 1939) and with a carapace width ranging from 15 to 36 mms. were used in this study. The cerebral ganglion and the optic ganglion were dissected out in the fixative. In the case of the eyestalks, prior to their removal, fixative was injected into the eyestalk from the proximal end, using a hypodermic syringe with a No. 26 needle. The majority of ganglia were fixed in Masson's Bouin (Foot 1933) or in 4% Formalin (Baker 1958). The tissues were dehydrated in ethanol, cleared in methyl benzoate, often with 1% celloidin added, and embedded in Paraplast (M.P. 56°C). Serial sections, 7 or 8 μ thick, were cut and mounted on glass slides.

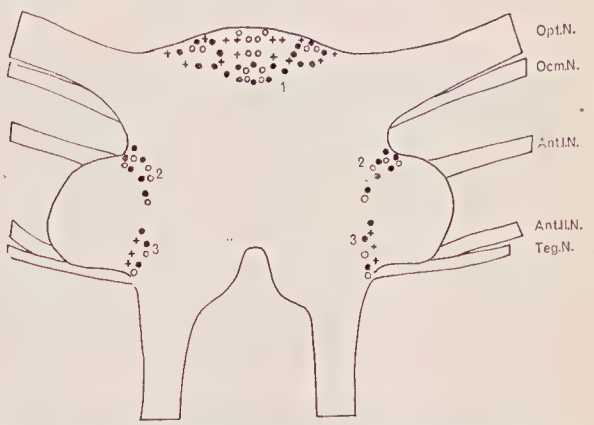

Fig. 1.—Diagram of the dorsal side of the brain of *P. gaimardii* indicating the location and the distribution of the neurosecretory cells. Opt. N., optic nerve; Ocm. N., oculomotor nerve; Ant. I. N., first antennary nerve; Ant. II. N. second antennary nerve; Teg. N., tegumentary nerve; +, large monopolar neurosecretory cells; •, medium monopolar neurosecretory cells, o small monopolar neurosecretory cells. Magnification x approximately 20.

Complete series of serial sections of either the brain or the eyestalks were stained with one of the following procedures:

(a) Paraldehyde fuchsin (PF). (Ewen 1962).
(b) Chrome-haematoxylin phloxine. (CHP). (Bargmann 1949).
(c) Mallory's Triple. (Pantin 1946).
(d) Azan. (Hubschman 1962).

The histochemical tests carried out on serial sections of either brain or optic ganglia included:
(a) the alloxan-Schiff technique for protein-bound amino groups after Yasuma and Ichikawa (1953).
(b) the performic acid-alcian blue technique for disulphide groups after Adams and Sloper (1956).
(c) the permanganate oxidation-alcian blue technique for disulphide groups after Arvy and Gabe (1962).
(d) the dihydroxy-dinaphthyl-disulphide (DDD) technique for sulfhydryl groups after Barrnett and Seligman (1952, 1954).
(e) the periodic acid-Schiff (PAS) technique after Hotchkiss and McManus (cf. Barka and Anderson 1963) for 1,2-glycol groups and a variety of other materials. Complete series of serial sections were treated with either (1) the standard method for PAS-reactive groups or (2) diastase digestion (2 hours at 26°C) followed by the standard method for the detection of glycogen.
(f) the alcian yellow-alcian blue technique for strongly acidic disulphide groups and weakly acidic glycol groups after Van De Kamer (1967).

The photographs were taken on a Wild Photoautomat fitted to a Wild M-20 microscope using either Kodak Plus-X Pan film or Ilford Pan F film.

RESULTS

In the brain and the commissural ganglia, there are three basic types of neurosecretory cells. The first type of cells are the large monopolar cells (Plates 1 and 2). These cells are oval in shape and they have mean diameter of 59.76 $\pm$ 8.60 μ. The cytoplasm of these cells is finely granular and shows an affinity for the Light Green component of the PF counterstain. In the cytoplasm, there are fine, purple PF-positive granules which reach their greatest concentration around the nucleus. In some cells, especially in the protocerebrum, vacuoles up to 16 μ across may occur in the outer part of the cytoplasm. These cells do not, in general, stain intensely with the PF technique but do possess distinct granules, suggestive of neurosecretory activity. The nuclei are oval, with a mean diameter of 21.16 $\pm$ 3.30 μ. With the PF technique, the nuclei are lightly stained with a greenish tinge. Only one nucleolus appears to occur per nucleus. The nucleoli are large, up to 5 μ in diameter and are Orange G - positive. The reactions of these cells to the three other histological stains are given in Table 1.

The medium neurosecretory cells of the brain are the most common type of neurosecretory cell in the brain (Plate 1). These cells are monopolar and are oval to elliptical in outline. They have a mean diameter of 36.96 $\pm$ 14.46 μ. The oval nuclei have a mean diameter of 16.27 $\pm$ 2.81 μ. There may be either one or two nucleoli. The cytoplasm of these cells is often coarsely granular and may have a great density of coarse, purple neurosecretory granules, notably concentrated around the nucleus. The nuclei have an affinity for Light Green and the nucleoli are stained orange with the PF technique. Small vacuoles up to 7 μ across are sometimes observed near the periphery of these cells. The reactions of these cells to the other histological techniques are given in Table 1.

The small neurosecretory cells are monopolar and are generally oval in shape. They have a mean diameter of 23.75 $\pm$ 2.74 μ and the oval nuclei have a diameter of 13.79 $\pm$ 1.50 μ. With the PF technique, the ground substance of the cytoplasm is stained a pale green, and within this, there occur distinct purple secretory granules.

TABLE 1.

Reactions of the neurosecretory cells of the brain and the commissural ganglia to the Chrome-haematoxylin phloxine technique (CHP), the Azan technique and Mallory's Triple technique.

Cells	Technique	Cytoplasm	Neurosecretory material	Nucleus	Nucleoli
Large Cells	CHP	pale red	purple	pink	red
	Azan	pale blue	grey-blue	pale red	red
	Mallory's Triple	reddish-purple	purple	pale purple	red
Medium cells	CHP	clear pink	purple to black	orange	red
	Azan	blue	grey-blue	brown	brick red
	Mallory's Triple	pink-purple	purple	pale red	red
Small cells	CHP	red	purple-black	pale red	red
	Azan	purple	reddish-purple	red	brick red
	Mallory's Triple	blue to reddish-purple	purple	pale purple	red

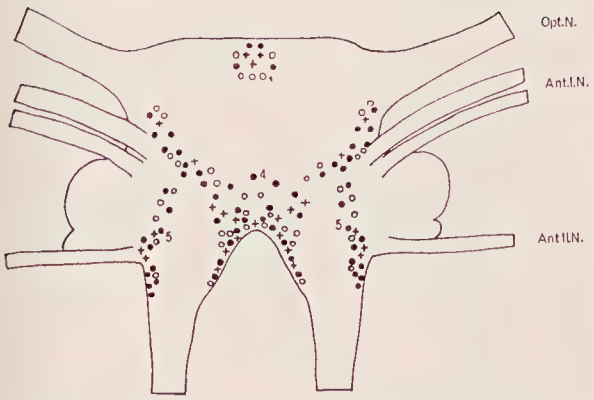

Fig. 2.—Diagram of the ventral side of the brain of *P. gaimardii*, indicating the location and distribution of the neurosecretory cells. Opt. N., optic nerve; Ant. I. N., First antennary nerve; Ant. II. N., Second antennary nerve; +, large monopolar neurosecretory cells; •, medium monopolar neurosecretory cells. o, small monopolar neurosecretory cells. Magnification x approximately 20.

A few small vacuoles, up to 4 μ across are sometimes observed in these cells. With the PF technique, the nuclei stain a pale green, while the nucleoli are red. For reactions of these cells to the other histological stains see Table 1.

Some neuroglial cells in the brain appear to be active secretory cells (Plate 3). The secretion appears as clustered deep purple granules, when stained with the PF technique. The secretory glial cells are predominantly located in and around the median group of protocerebral neurosecretory cells (Group I), though some are also located in and near Group 4 of the brain. The pathway(s) by which such secretion is discharged is unknown, though there are indications that secretory granules from the protocerebral group of neuroglial cells are transported along the optic nerve. The neuroglial cells have oval nuclei which stain a pale blue with the PF technique.

The principal region of neurosecretory cells on the dorsal side of the brain is the median group of cells in the protocerebrum (Group 1): (Figure 1). This region contains a considerable number of large neurosecretory cells. The regions of neurosecretory cells around the olfactory lobes of the brain, although continuous, can be divided into two groups, the anterior group (Group 2) and the posterior group (Group 3) for each side of the dorsal aspect of the brain.

The ventral aspect of the brain is notably richer in neurosecretory cells (Figure 2). Anteriorly, neurosecretory cells are present in the continuation to the ventral surface of the median protocerebral group of cells (Group 1). The most prominent area for the localization of neurosecretory cells on the ventral side of the brain is the central group (Group 4). This central group extends posteriorly to where the circumoesophageal connectives leave the brain. Anteriorly and posteriorly of the base of the second antennal nerve, a small region of neurosecretory cells (Group 5) is located. The tritocerebral commissural ganglia are situated on the circum-oesophageal connectives. They occur as ganglionic swellings anterior to the tritocerebral commissures. In the ganglia, both medium and small neurosecretory cells are found (Figure 3). The greatest concentration of these cells occurs on the dorso-lateral margins of the anterior sides of the ganglia.

Neurosecretory Cells of the Eyestalk

In the eyestalk, four types of neurosecretory cells are identified. The large monopolar neurosecretory cells of the eyestalk are oval in outline and have a mean diameter of 45.15 $\pm$ 4.90 μ (Plate 4). The cytoplasm of these cells varies in texture. In many of these cells, the cytoplasm is granular with fine purple secretory granules in the cytoplasm and in such cases the granules cytoplasm. Other cells of this type may have coarser granules in the cytoplasm and in such cases the granules are not so markedly concentrated around the nucleus (Plate 4). Frequently in such cells, vacuoles are present near the peripheries of the cells. Like the large monopolar cells of the brain, the ground substance of the cytoplasm of the eyestalk cells, shows an affinity for Light Green. The nuclei are oval and have a mean

Fig. 3.—Dorsal view of a tritocerebral commissural ganglion, showing the position of the neurosecretory cells. •, medium monopolar neurosecretory cells; o, small monopolar neurosecretory cells. Magnification x approximately 120.

TABLE 2.

Reactions of the neurosecretory cells of the eyestalks to the Chrome-haematoxylin phloxine technique (CHP), the Azan technique and Mallory's Triple Technique.

Cells	Technique	Cytoplasm	Neurosecretory Material	Nucleus	Nucleoli
Large cells	CHP	pink	purple	pale red	red
	Azan	blue	purple	brick red	pale red
	Mallory's Triple	maroon	purple	red-maroon	red
Medium oval cells	CHP	pale pink	purple	pale red	red
	Azan	grey	blue	brick red	red
	Mallory's Triple	maroon	purple	red	red
Medium elongated cells	CHP	pink	purple	red	red
	Azan	blue-grey	blue	purple	pale red
	Mallory's Triple	maroon	blue-purple	purple	red-purple
Small cells	CHP	pale pink	purple-black	red	deep red
	Azan	blue	blue-purple	magenta	pink
	Mallory's Triple	pale purple	purple	deep red	red

diameter of 18.47 $\pm$ 2.67 μ. There is one nucleolus per nucleus. The nucleoli are large, up to 5 μ in diameter and are stained orange with the PF technique.

The medium monopolar neurosecretory cells of the eyestalk are of two different types. The medium oval cells of the eyestalk are more prevalent than the medium elongated cells of the eyestalk.

The medium oval cells have a mean diameter of 28.95 $\pm$ 3.12 μ. Their cytoplasm is stained a light green with the PF technique, and has in it fine purple secretory granules. Some cells have vacuoles in the cytoplasm and when this vacuolated condition occurs, the secretory granules are coarse. The nuclei have a diameter of 15.27 $\pm$ 1.67 μ and are generally stained a pale green. There is one nucleolus per nucleus.

The medium elongated neurosecretory cells are generally pear-shaped in outline. The mean length of these cells is 29.68 $\pm$ 2.46 μ, while the mean width of these cells is 15.82 $\pm$ 1.81 μ. The cytoplasm is finely granular and stained a light green. In the cytoplasm both fine and coarse purple secretory granules occur. The nuclei are oval in outline and have a mean diameter of 14.94 $\pm$ 1.73 μ. One small nucleolus occurs per nucleus.

The small monopolar cells of the eyestalk are oval to elongated in outline. They have a mean diameter of 18.26 $\pm$ 2.82 μ. The cytoplasm is stained a pale green with the PF technique, with a limited number of purple secretory granules in the cytoplasm. The nuclei are Light Green-positive and have a mean diameter of 12.35 $\pm$ 1.71 μ.

The reactions of these four types of cells to the three other histological staining techniques are given in Table 2.

The principal neurohaemal organ of the eyestalk, the sinus gland is located in the dorsal posterior side of the optic ganglia, adjacent to the Medulla Interna (Plate 5). The sinus gland is a flattened ovoid in shape with the flattening occurring in the dorso-ventral plane. In transverse cross section, the sinus gland is a flattened ellipse in shape. The central part of the gland is occupied by the blood sinus. The swollen axonal endings containing the neurosecretory material are separated from the blood sinus by a thin basement membrane, which is stained dark green with the PF technique. In mature animals, the sinus gland is about 300 μ long, while in transverse section it is about 120 μ wide.

The size of the granules present in the sinus gland varies considerably with a consistent gradient from the external to the internal surfaces of the organ. The larger granules, in the outer part of the gland, are approximately 6 to 7 μ in diameter and are stained a deep purple with the PF technique. Smaller purple granules, 0.5 to 1 μ in diameter, are located near the internal surfaces of the gland. Close to the internal surfaces of the gland, the secretory granules are very fine. There is a difference in the staining properties of the secretory material between the outer and the inner parts of the gland. The large granules stain a deep purple with the PF technique. Smaller purple granules, are stained greenish-blue to a deep green. Near the basement membrane homogeneous, light green secretory material is also found. The changes in the staining properties of the secretory material in the sinus gland may indicate changes in the chemical nature of the neurosecretory material prior to or at the site of release. When stained with the CHP technique, large lilac globules are observed. Scattered purple globules are also present close to the internal surfaces of the gland, while very strongly phloxinophilic granules are located in the outer parts of the gland.

Three types of secretory materials were observed in the sinus gland, when the Mallory's Triple staining procedure was used. The predominant type of secretory

TABLE 3.

Reactions of the secretory materials of the neurosecretory cells of the brain and the eyestalks and of the sinus gland to the various histochemical tests.

Test	Brain			Eyestalks				Sinus gland	
	Large cells	Medium cells	Small cells	Large cells	Medium oval cells	Medium elongated cells	Small cells	Region A	Region B
Alloxan-Schiff	+	+	+	+	++	+	+	++++	++
PFAAB									
POAB	+	++	+	+	++	++	+	+++++	++
DDD	+	+	+	+	±	+	±	+	—
PAS	+	++	+	+	±	±	—	—	+
PAS-diastase	—	—	—	—	—	—	—	—	—
Alcian yellow-Alcian Blue	Blue	Blue	Pale blue	Blue	Blue	Blue	Pale blue	Green-yellow	Green-blue

Fig. 4.—Dorsal view of the right eyestalk of *P. gaimardii*, showing the location and distribution of the neurosecretory cells and the sinus gland (S.G.) ⊕, large monopolar neurosecretory cells; □, medium monopolar neurosecretory cells; ■, medium elongated neurosecretory cells; Δ, small monopolar neurosecretory cells; M.E., medulla externa; M.I., medulla interna; M.T., medulla terminalis. Magnification x approximately 35.

material stains with the acid fuchsin component. Near the basement membrane of the gland, fine purple and small orange granules are present.

With the Azan technique, the predominant type of secretory material is in the form of large brick-red granules with some orange granules within this material. Near the basement membrane, fine purple and blue granules are found. There is a change from the purple to the blue colour with decreasing distance from the basement membrane.

The sinus gland tract is clearly visible in sections, leading into the sinus gland. Near the gland it is approximately 35 μ wide. Within the tract there are aggregations of large fuchsinophilic granules, though the intensity of their colour is not as intense as that of the large purple granules in the sinus gland.

The presence of allochthonous cells in the sinus gland was revealed by staining their nuclei with the Feulgen reaction after fixation of the eyestalk in neutral formalin. The cells were largely confined to the outer half or so of the sinus gland and reached their greatest density near the outer surface of the gland. The most common type of nucleus encountered was oval in shape and had a diameter of approximately 8 μ. Close to the outer surface of the sinus gland a second type of nucleus was encountered. These nuclei were also small but were elongated in shape. The oval nuclei may be the nuclei of neuroglial cells, while the elongated nuclei may be the nuclei of connective tissue cells associated with the connective tissue sheath of the sinus gland. The neuroglial cells of the sinus gland do not appear to be active secretory components as observed by Adiyodi (1969).

The sinus gland lies on the dorsal surface of the optic ganglia, opposite the Medulla Interna (Figure 4). A group of neurosecretory cells is found in the Medulla Externa occupying the dorsal and ventral posterior side of this region, near the junction of the Medulla Externa and the Medulla Interna (Figures 4 and 5). In the Medulla Interna, near the sinus gland, on the dorsal surface there is an extension of neurosecretory cells from Group E4 of the Medulla Terminalis, while on

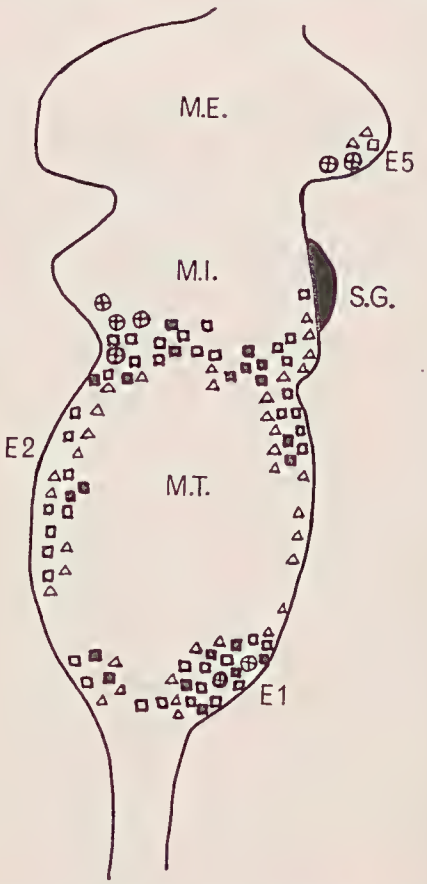

Fig. 5.—Ventral view of the right eyestalk of *P. gaimardii*, showing the location and distribution of the neurosecretory cells and the sinus gland (S.G.) Symbols, legend and magnification identical to that of Figure 4.

the ventral posterior surface of the Medulla Interna, Group E4 also extends from the Medulla Terminalis. On the ventral anterior surface of the Medulla Interna, neurosecretory cells extend from Group E2 of the Medulla Terminalis.

Three groups of neurosecretory cells are found in the Medulla Terminalis, making this the most notable region for neurosecretory cells in the eyestalk. On the ventral anterior surface of the Medulla Terminalis, Group E2 is located, while on the posterior ventral surface, Group E4 extends back proximally to join with Group E1. Group E1 is located on the proximal margins of the Medulla Terminalis and constitutes the Medulla Terminalis Ganglionic X-organ.

Histochemical Observations of the Neurosecretory cells of the Brain and the Eyestalk and of the Sinus Gland.

In this series of observations, the sinus gland is divided into two regions. Region A constitutes that region containing rather large granules, 6-7 μ in diameter, while Region B constitutes that region of the sinus gland adjoining the basement membrane and containing the fine secretory granules. The results of the reactions in the neurosecretory cells are for the secretory material only. The results of the tests are given in Table 3.

Alloxan-Schiff. This test for protein-bound amino groups is recommended by Barka and Anderson (1963) as a general protein staining technique. Proteins are stained from pink to red. In general, the secretory material of the neurosecretory cells of the brain and the eyestalks was only mildly stained, while that of the sinus gland was stained a deep red indicating the presence of significant amounts of protein.

Performic acid Alcian Blue and Permanganate-oxidation Alcian Blue.

The results of both of these tests for disulphide groups are basically similar. As in the alloxan-Schiff test, the sinus gland proved to be the most active neurosecretory region.

DDD Reaction. This reaction indicates the presence of sulfhydryl groups. Using Fast Blue B as the diazonium salt, the presence of high concentrations of -SH groups is indicated by a violet-blue or blue colour. However, in this study, regions of high reactivity were indicated only by a red colour.

Periodic acid-Schiff. This test demonstrates the presence of carbohydrates and a number of related substances. such as some neutral mucopolysaccharides, some glycolipids and glycoproteins. Used in conjunction with diastase digestion pre-treatment, the PAS technique may demonstrate the presence of glycogen. From the results of the PAS and the PAS-diastase tests, it appears that the reactivity of granular material in the cells and in the sinus gland is largely due to the presence of glycogen.

Alcian Yellow-Alcian Blue. This test distinguishes between weakly acidic glycol groups and the strongly acidic S-S groups in proteins. The weakly acidic glycol groups in neurosecretory material are stained blue and the strongly acidic S-S groups are stained yellow. The neurosecretory material in *P. gaimardii* in the cell perikarya contains a predominance of weakly acidic glycol groups while that in the sinus gland contains a predominance of strongly acidic S-S groups.

DISCUSSION

In the brain and tritocerebral commissures of the crab, *Paragrapsus gaimardii,* three types of neurosecretory cells could be distinguished. The number of types of neurosecretory cells detected in the brain of brachyurans investigated to date, varies from one to three. Only one distinct type of neurosecretory cell was reported by Szudardky (1963), while two types have been reported by Enami (1951), Parameswaran (1956), Miyawaki (1960) and Baid, Hafidh and Dabagh (1967). Three types of cells have been reported by Inoue (1957) and Matsumoto (1958).

The large monopolar cells of the brain of *P. gaimardii* may correspond to the α neurosecretory cells of Enami (1951), the A cells of Parameswaran (1956), Inoue (1957) and of Matsumoto (1958), the median cells of Miyawaki (1960) and the B3 cells of Szudardky (1963). The medium cells of the brain of *P. gaimardii* may correspond with the β cells of Enami (1951), the B cells of Parameswaran (1956), Inoue (1957) and Matsumoto (1958) and the B2 cells of Szudardky (1963). The small cells of the brain of *P. gaimardii* may similarly correspond to the γ neurosecretory cells of Enami (1951), the D cells of Inoue (1957), the E cells of Matsumoto (1958), the small cells of Miyawaki (1960) and of Baid, Hafidh and Dabagh (1967).

The regions where neurosecretory cells occur in the brain are basically similar to those reported for *Sesarma dehaani* by Enami (1951), for *Pachygrapsus crassipes* by Inoue (1957) for *Paratelphusa hydrodromous* by Parameswaran (1956) for *Potamon dehaani* and *Neptunus trituberculatus* by Matsumoto (1958) and for *Rhithropanopeus harrisi* by Szudardky (1963). The routes of axonal transport of the neurosecretory material synthesized in the neurosecretory cells of the brain of *P. gaimardii* are not clearly known, though there are indications that neurosecretory material is transported along the optic nerve from cells in Groups 1 and 2. This is similar to the results of Bliss and Welsh (1952) and Bliss, Durand and Welsh (1954).

The phenomenon of gliosecretion is noticeable in the brain of *P. gaimardi.* Indeed gliosecretion appears to be a more active process in the brain than in the optic ganglia. The routes of discharge or transport of the gliosecretion in *P. gaimardii* are not known. Gliosecretion has been reported in crabs by Szudardky (1963) and by Adiyodi (1969). Adiyodi (1969) observed that the gliosecretion underwent cyclical changes in relation to the moulting cycle, being most abundantly present in adult female *Paratelphusa hydromous* in the late C3 and early C4 stages (Intermoult) of the moult cycle. These were the stages in which *P. gaimardii* was examined. It is interesting to note that the phenomenon of gliosecretion by the allochthonous cells of the sinus gland as reported by Adiyodi (1969) was not clearly evident in *P. gaimardii.*

In the eyestalk of *P. gaimardii,* four types of neurosecretory cells were detected. The two types of medium neurosecretory cells are generally similar in their staining properties but differ notably in their shape. In the eyestalk of crabs, investigators have distinguished a number of different types of cells. The number of types varies

from two (Miyawaki 1956a, 1960) to six (Potter 1958, Matsumoto 1958). Although, as in the case of the neurosecretory cells of the brain, it is difficult to relate the neurosecretory cells of the eyestalk of *P. gaimardii* to those reported in the eyestalk of other crabs by other authors, some similarities can be discerned. The large cells of the eyestalk of *P. gaimardii* may correspond to the β cells of Enami (1951), the giant cells of Miyawaki (1956a) the α and the β cells of Matsumoto (1958) the Type I and Type II cells of Potter (1958), the median cells of Miyawaki (1960), the α cells of Valente (1959) anr the B3 cells of Szudardky (1963). The medium oval and medium elongated neurosecretory cells of *P. gaimardii* may correspond to the α cells of Enami (1951), the B cells of Matsumoto (1958) and the B2 cells of Szudardky (1963). The medium elongated cells are also similar to the δ cells of Matsumoto (1958). The small cells of the eyestalk of *P. gaimardii* may be similar to the γ cells of Enami (1951), and of Matsumoto (1958), the Da Fano cells of Miyawaki (1956a), the Type IV cells of Potter (1958), the small cells of Miyawaki (1960) and the B1 cells of Szudardky (1963).

The distribution of the neurosecretory cells in the eyestalk of *P. gaimardii* resembles that figured for the crab, *Gecarcinus lateralis* (Bliss and Welsh 1952, Bliss Durand and Welsh 1954), except that Group E1 in *P. gaimardii* is fused with Group E4. This condition is somewhat similar to that reported for *Sesarma intermedia* by Matsumoto (1958). The E5 Group of cells reported by Matsumoto (1958) is present in *P. gaimardii* but Group E6 is absent.

The presence of different types of neurosecretory materials in the sinus gland of crabs has been reported by a number of investigators (Enami 1951, Bliss, Durand and Welsh 1954, Potter 1954, 1958, Rehm 1959, Szudardky 1963). In intermoult *P. gaimardii*, using the PF technique, three types of secretory materials were observed. The predominant type of secretory material is basophilic and occurs as large globules, while near the basement membrane two types of acidophilic material are present. Three types of secretory materials are also detectable in the sinus gland, using the CHP, Mallory's Triple and the Azan techniques. A multiplicity of secretory material types, as reported by Potter (1958), both in the cells of the Medulla Terminalis X-organ and in the sinus gland was not observed in *P. gaimardii*. The PF-positive secretory material in the sinus gland of *P. gaimardii* may correspond to that of the A and AB endings of *Carcinus maenas* (Rehm 1959) and to the fuchsinophilic material of *Rhithropanopeus harrisi* (Szudardky 1963). The acidophilic material near the basement membrane of the sinus gland may likewise correspond to the B and D endings of Rehm (1959).

Whether there is a change in the chemical nature of the neurosecretory material in the process of storage or of release or of both, as has been suggested by Enami (1951), and by Szudardky (1963), cannot at present be ascertained for *P. gaimardii*. However, it is clear from this study and from an earlier one (Lake 1969), that a considerable modification in the histochemical properties of the neurosecretory material during the process of axonal transport does occur in *P. gaimardii*.

The presence of allochthonous cells in the sinus gland of *P. gaimardii* is established. These cells are of two basic types; those on the periphery of the sinus gland and which may be connective tissue cells and those within the sinus gland itself, which may be neuroglial cells. The neuroglial or 'allochthonous' cells of the sinus gland have been suggested by Enami (1951) and Miyawaki (1956a) to produce secretory material, or to be involved in the process of release of secretory material (Hodge and Chapman 1958) or to be involved in the process of both elaboration and transformation of the secretory material (Gabe 1966). Adiyodi (1969) has recently produced evidence for the idea that allochthonous cells of the sinus gland actively elaborate and release their own secretory products.

The presence of allochthonous cells or neuroglial cells in the sinus gland of crabs has been shown at the electron microscope level by Hodge and Chapman (1958) and Meusy (1968) and in crayfish by Shivers (1967) and Bunt and Ashby (1967). It is interesting to note that Meusy (1968) observed that the cytoplasm of the neuroglial cells was very rich in glycogen. This abundance of glycogen may correspond to the gliosecretion or part of the gliosecretion reported by Adiyodi (1969).

The histochemical tests applied to serial sections of the cephalic neurosecretory system of *Paragrapsus gaimardii* reveal that the neurosecretory material is a protein (alloxan-Schiff), rich in S-S groups (Performic acid-Alcian blue and permanganate oxidation-Alcian Blue), with some SH groups present (DDD). The PAS test reacts with granular material in the perikarya of neurosecretory cells and this reaction is abolished by pre-treatment with diastase. Thus weakly acidic 1,2 glycol groups may be present in the neurosecretory material, especially when the material is in the cell perikarya but not when it is in the neurohaemal organ. The presence of PAS-positive material in the neurosecretory cells of crabs has been observed by Miyawaki 1956b, c) and by Gabe (1952, 1966). As is the case in *P. gaimardii*, Miyawaki (1956c) found that the degree of PAS-reactivity was greater in the cell perikarya than in the neurohaemal sites (sinus gland). The PAS-positive material in *Telmessus cheiragonus* was metachromasia-negative and diastase-resistant (Miyawaki 1956c). Miyawaki (1956b, c) concluded that the PAS-positive material was probably a neutral mucopolysaccharide or a mucoprotein. The PAS-positive material in *P. gaimardii* is not diastase-resistant. Glycol groups may be associated with the neurosecretory material or alternatively as in other cells of the cerebral nervous system, glycogen is commonly present in neurosecretory cells.

That the neurosecretory material of crustaceans is a protein, rich in disulphide groups has been suggested from histochemical evidence by Rehm (1959), and Lake (1969, 1970). Using chromatographic techniques, Otsu (1965) and Otsu and Sonobe (1965) have produced evidence to indicate that chromactivating substances from the brain and the thoracic ganglion of the crab *Eriocheir japonicus*, are polypeptides, of 10 to 13 amino acids, including cystine and rich in S-S Bonds.

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REFERENCES

ADAMS, C. W. M., and SLOPER, J. C., 1956: The hypothalamic elaboration of posterior pituitary principles in man, the rat and dog. Histochemical evidence derived from a performic acid-alcian blue reaction for cystine. *J. Endocrinol.*, vol. **13**, pp. 221-8.

ADIYODI, R. G., 1969: Gliosecretion in the crab, *Paratelphusa hydrodromous* (Herbst.). *Gen. Comp. Endocrinol., vol.* **13**, pp. 306-8.

ARVY, L., and GABE, M., 1962: Histochemistry of the neurosecretory product of the Pars Intercerebralis of Pterygote insects. In *Neurosecretion* (edited by H. Heller and R. B. Clark), pp. 331-44. Academic Press, New York.

BAID, I. C., HAFIDH, R. A., and DABAGH, S., 1967: Studies on the neurosecretory cells in the cerebral ganglion of *Potamon magnum magnum* (Pretzman). *Experientia,* vol. **23**, p. 564.

BAKER, J. R., 1958: *Principles of Biological Technique.* Methuen and Co., London.

BARGMANN, W., 1949: Uber die neurosekreotische Verknupfung von Hypothalamus und Neurohypophyse. *Z. Zellforsch.,* vol. **34**, pp. 610-34.

BARKA, T., and ANDERSON, P. J., 1963: *Histochemistry: Theory, Practice and Bibliography.* Hoeber Medical Division, Harper and Row, New York.

BARRNETT, R. J., and SELIGMAN, A. M., 1952: Histochemical demonstration of protein-bound sulfhydryl groups. *Science,* vol. **116**, p. 323.

————, 1954: Histochemical demonstration of sulfhydryl and disulfide groups of protein. *J. Natl. Cancer Inst.,* vol. **14**, pp. 769-803.

BLISS, D. E., and WELSH, J. H., 1952: The Neurosecretory system of brachyuran Crustacea. *Biol. Bull.,* vol. **103**, pp. 157-69.

BLISS, D. E., DURAND, J. P., and WELSH, J. H., 1954: Neurosecretory systems in decapod Crustacea. *Z. Zellforsch.,* vol. **39**, pp. 520-36.

BUNT, A. H., and ASHBY, E. A., 1967: Ultrastructure of the sinus gland of the crayfish, *Procambarus clarkii. Gen. Comp. Endocrinol.,* vol. **9**, pp. 334-42.

DRACH, P., 1939: Mue et cycle d'intermue chez les Crustacés Decapodes. *Ann. Inst. Oceanogr.* vol. **19**, pp. 103-91.

ENAMI, M., 1951: The sources and activities of two chromatophorotropic hormones in crabs of the genus *Sesarma.* II. Histology of incretory elements. *Biol. Bull.,* vol. **101**, pp. 241-58.

EWEN, A. B., 1962: An improved aldehyde fuchsin technique for neurosecretory products in insects. *Trans. Amer. Micr. Soc.,* vol. **81**, pp. 94-6.

FOOT, N. C., 1933: The Masson trichrome staining methods for routine laboratory use. *Stain. Technol.,* vol. **8**, pp. 101-10.

GABE, M., 1952: Particularités histochimiques de l'organe de Hanstrom (organe X) et de la glande du sinus chez quelques Crustacés Decapodes. *Compt. Rend.,* vol. **235**, pp. 90-2.

————, 1966: *Neurosecretion.* Pergamon Press, Oxford.

HANSTRÖM, B., 1937: Die Sinusdrüse und der hormonal bedingte Farbwechsel der Crustaceen. *Kgl. Svenska. Vetenskapsakd. Hdl.* (3), vol. **16**, part 10, pp. 1-99.

————, 1947: The brain, the sense organs and the incretory organs of the head in the Crustacea Malacostrac. *Lunds. Univ. Arsskr. N.F. Adv.* 2, vol., **43**, part 9, pp. 1-45.

HODGE, M., and CHAPMAN, G. B., 1958: Some observations on the fine structure of the sinus gland of a land crab, *Gecarcinus lateralis. J. Biophys. Biochem. Cytol.,* vol. **4**, pp. 571-4.

HUBSCHMAN, J. H., 1962: A simplified Azan process well suited for crustacean tissue. *Stain. Technol.,* vol., **37**, pp. 379-80.

INOUE, H., 1957: On the neurosecretory cells of *Pachygrapsus crassipes. Mem. Gakugei. Fac. Akita. Univ. Nat. Sci. vol.* **7**, pp. 84-92.

LAKE, P. S., 1969: Changes in the histochemical nature of neurosecretory material during axonal transport in the crab. *Paragrapsus gaimardii. Experientia,* vol. **25**, p. 1314.

————, 1970: Histochemical studies of the neurosecretory system of *Chirocephalus diaphanus.* Prévost (Crutacea: Anostraca). *Gen. Comp. Endocrinol.* vol. **14**, pp. 1-15.

MATSUMOTO, M., 1958: Morphological studies on the neurosecretion in crabs. *Biol. J. Okayama. Univ.,* vol. **4**, pp. 103-76.

MEUSY, J., 1968: Précisions nouvelles sul l'ultrastructure de la glande du sinus Crustacé Decapode Brachyoure, *Carcinus maenas. Bull. Soc. Zool. France,* vol. **93**, pp. 291-9.

MIYAWAKI, M., 1956a: Histological observations on the incretory element in the eyestalk of a Brachyura, *Telmessus cheiragonus. J. Fac. Sci. Hokkaido. Univ. Ser. VI. Zool.* vol. **12**, pp. 325-32.

————, 1956b: PAS-positive material in the neurosecretory cells of the crab. *Telmessus cheiragonus. Annot. Zool. Japon.* vol. **29**, pp. 151-4.

————, 1956c: Cytological and cytochemical studies on the neurosecretory cells of a Brachyura, *Telmessus cheiragonus. J. Fac. Sci. Hokkaido. Univ. Ser. VI. Zool.* vol. **12**, pp. 516-20.

————, 1960: On the neurosecretory cells of some decapod Crustacea. *Kumamoto. J. Sci. Ser. B. Sec. 2.* vol. **5**, pp. 1-20.

ÖTSU, T., 1965: Component amino acids of chromatophore concentrating hormones from Decapoda, Crustacea. *Naturwissenschaften,* vol. **52**, pp. 187-8.

ÖTSU, T., and SONOBE, H., 1965: Component amino acids of chromactivating substances in the thoracic ganglion of the crab. *Eriocheir japonicus. Annot. Zool. Japon.* vol. **38**, pp. 127-33.

PANTIN, C. F. A., 1946: Notes on Microscopical technique *for zoologists.* Cambridge Unv. Press, London.

PARAMESWARAN, R., 1956: Neurosecretory cells of the central nervous system of the crab, *Paratelphusa hydrodromous. Quart. J. Micr. Sci.* vol. **97,** pp. 75-82.

POTTER, D., 1954: Histology of the neurosecretory system of the blue crab, *Callinectes sapidus. Anat. Rec.* vol. **120,** p. 216.

————, 1958: Observations on the neurosecretory system of portunid crabs. 2nd. Internat. Symp. Neurosekretion. (Edited by W. BARGMANN, B. HANSTROM, E. SCHARRER, and B. SCHARRER), pp. 113-18. Springer, Berlin.

REHM, M., 1959: Observations on the localisation and chemical constitution of neurosecretory material in nerve terminals in *Carcinus maenas. Acta. Histochem.* vol. **7,** pp. 88-106.

SHIVERS, R. R., 1967: Fine structure of crayfish optic ganglia. *Univ. of Kansas Science Bull.* vol. **47,** pp. 677-733.

SZUDARSKY, M., 1963: Neurosecretion of the central nervous system of the crab, *Rhithropanopeus harrisi* (Gould) subspecies *tridentata* (Maitl.). *Acta. Biol. et. Med. Soc. Sci. Gedan.* vol. 7, pp. 1-32.

VALENTE, D., 1959: Contribuçâo para o estudo da Neurosecreçâo nos crustáceos. *Boletin. Fac. Fil. Ciên. Letr. Univ. Sâo Paulo.* No. 232, Zoologia No. 22, pp. 5-74.

VAN DE KAMER, J. C., 1967: Changes in the hypothalmo-hypophysial system of common frogs, under osmotic stress and in a temperature experiment. In IV. *Internat. Symp. Neurosecretion.* (Edited by F. STUTINSKY), pp. 95-100, Springer-Verlag, Berlin.

YASUMA, A., and ICHIKAWA, T., 1953: Ninhydrin-Schiff and alloxan-Schiff staining. A new histochemical method for protein. *J. Lab. Clin. Med.* vol. **41,** pp. 296-9.

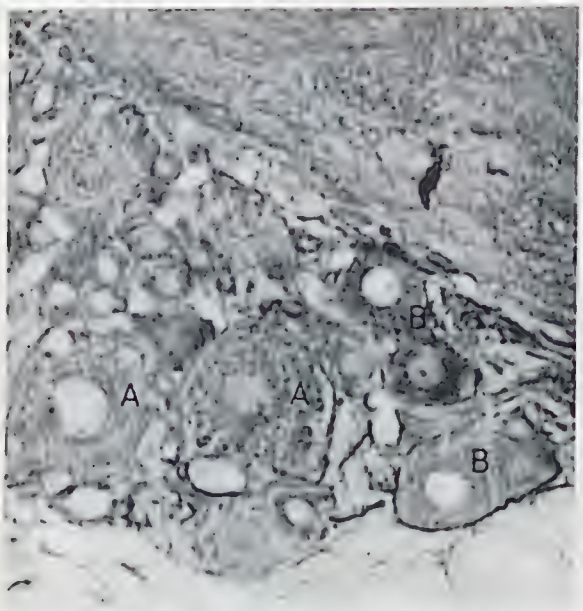

Plate 1.—Longitudinal section of Region 4 of the brain of *P. gaimardii*, showing large monopolar neurosecretory cells (A) and medium monopolar neurosecretory cells (B). Stained with paraldehyde-fuchsin technique. Magnification x 800.

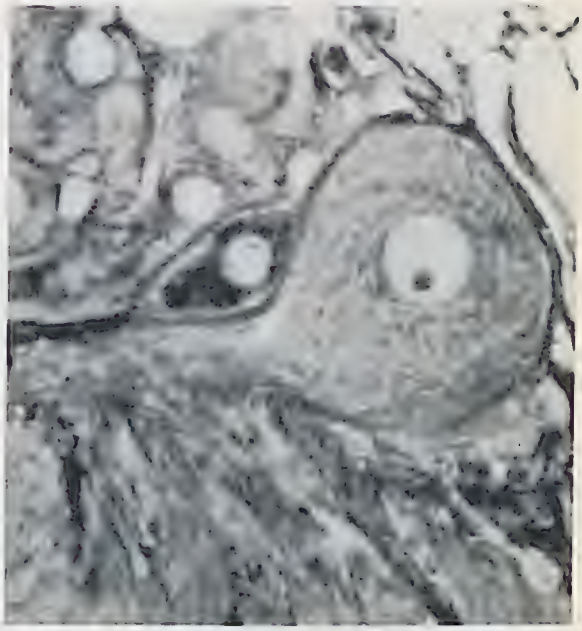

Plate 2.—View of large monopolar neurosecretory cell in Region I of the protocerebrum of *P. gaimardii*. Stained with paraldehyde-fuchsin technique. Magnification x 1,760.

Plate 3.—Neuroglial cells displaying signs of secretory activity. They are located near Region I of the protocerebrum of *P. gaimardii*. Stained with the paraldehyde-fuchsin technique. Magnification x 1,500.

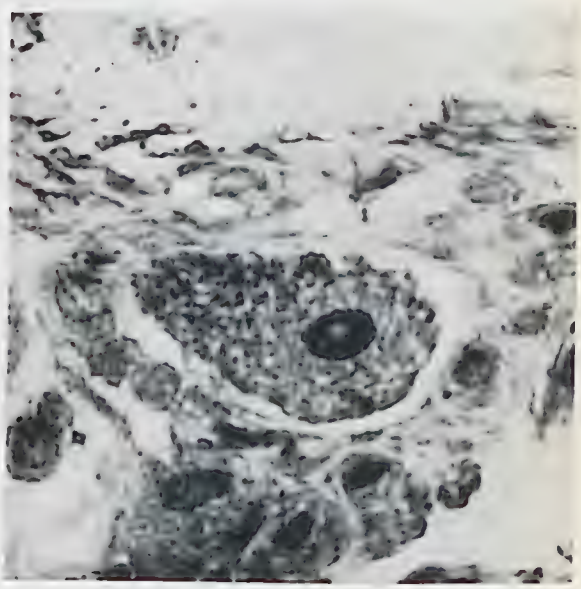

Plate 4.—Large monopolar neurosecretory in position EI of the eyestalk of *P. gaimardii*. Stained with Mallory's Triple technique. Magnification x 1,600.

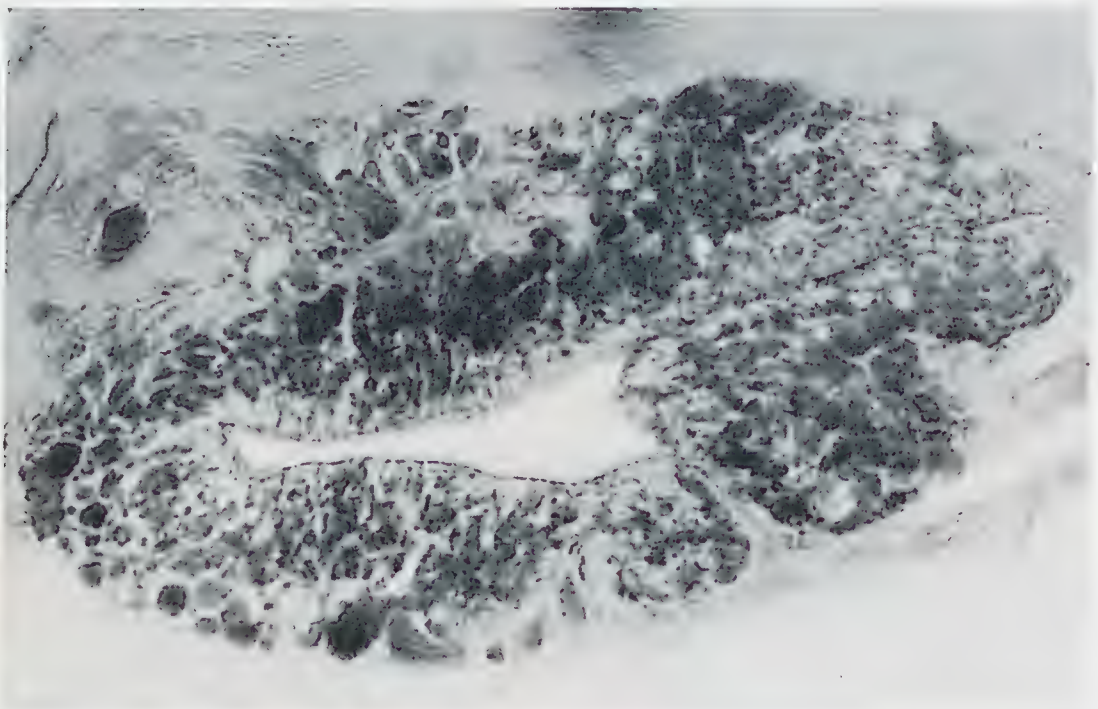

Plate 5.—Longitudinal section of the sinus gland of *P. gaimardii*. Stained with the alcian yellow/alcian blue technique. Magnification x 800.

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STRUCTURE OF THE PRECAMBRIAN ROCKS OF THE DAVEY RIVER AREA, SOUTH-WESTERN TASMANIA

By

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ABSTRACT

The Precambrian quartzites and schists of the Davey River area are characterised by subvertical foliations and garnet grade metamorphism. Three metamorphic events are followed by several episodes of flexural refolding.

INTRODUCTION AND ACKNOWLEDGEMENTS

Detailed lithological and structural mapping has been made at the Davey River, between its junction with the Crossing River and the Davey Saddle, a ridge overlooking the sea at Bond Bay, in Southwest Tasmania, about 70 miles south of Frenchman's Cap.

The field work was conducted as part of a regional survey for the Hydro-Electric Commission under the general supervision of Mr G. E. A. Hale and Dr K. L. Burns. The logistic assistance of the Commission, particularly in respect of transport and base facilities, made the work possible. The assistance of officers of the Commission, given in a multitude of ways, is gratefully acknowledged. Assistance in the field was provided by Messrs J. G. Remfry, D. R. Edgecombe and R. A. Watson and the work incorporates some of their mapping. Dr M. J. Rickard mapped the quartzite ridge Southeast of Hells Gates and led a traverse down the bed of the Davey River from the Crossing Junction. The bulk of the field mapping is by C. J. Maclean, assisted by E. A. Bowen. Compilation of this report has been by C. J. Maclean in respect of the petrology and structure of the Davey River with assistance from Dr K. L. Burns in respect of the regional significance.

TEXTURAL HISTORY

From the manner of interaction of the various metamorphic layerings in thin section and in the field, it is possible to recognise the textural events as tabulated below. These events are grouped together into phases, F1 to F6, which are groups of events of allied character. Each phase is not a single episode of metamorphism of deformation, but consists of several related episodes. Preliminary thin section examination reveals garnet and albite to be pre-tectonic to S2.

Phase	*Symbol*	*Textural Event*
F1	S1	(a) In schists, a mica foliation parallel to bedding. (b) In quartzite, a flat-quartz foliation with a parallel mica foliation. (c) Mesoscopically, S1 is a lithological layering (transposition foliation) with the foliae as discontinuous lenticles. This is the marked banding exposed in cliffs at Hells Gates on the Davey River.
	L1	There are several lineations in this group, probably of different ages. Various textural expressions are: (a) Micro crenulations (in schists) (b) Surface rodding on S1 in quartzites (c) Crystallographic orientation of quartz (d) Colour streaking in quartzite.
F2	S2	(a) In schists, axial planes to crenulated micas (b) In quartzites, axial planes to crenulations in the flat-quartz foliation (S1), with a parallel mica foliation. (c) Mesoscopically, S2 is a crenulation cleavage with transposition of lithology confined to small areas where S2 is intensely developed.
	L(1, 2)	(a) In quartzite, ribbing due to the crenulated S1 or to intersections of S1 and S2. (b) In schists, micro crenulations of S1.
F3	S3	In quartzite, a penetrative foliation due to dimensional orientation of quartz grains and mica flakes.
F4	S4	In quartzite and schist, a micro jointing or fracture cleavage as planes spaced from ½ to 1 inch apart. There is no mineral growth on these planes so this event is probably post-metamorphic. The orientation is east-west and the dip to the south.
F5 & F6		Late stage folds refolding structures of F2. The fold systems include:
F5		Open flexural folds on vertical axial surfaces which strike North-South and East-West.
F6		Kink bands which strike northeast and southeast.

Events F1 to F3 are syn-metamorphic and are probably Precambrian in age. The remaining phases are later and could be Precambrian and/or Palaeozoic.

The general textural sequence agrees with descriptions of Frenchman's Cap by Spry (1963) and Bond Bay (Spry 1969). The same general sequence is recorded from Cradle Mountain (Gee, Marshall and Burns, pers. comm.). This implies a considerable uniformity in the textural history of the Tasmanian Precambrian of the Tyennan Nucleus as the Davey River is near the southern extremity, while Cradle Mountain is at the northern. The general appearance and character of the

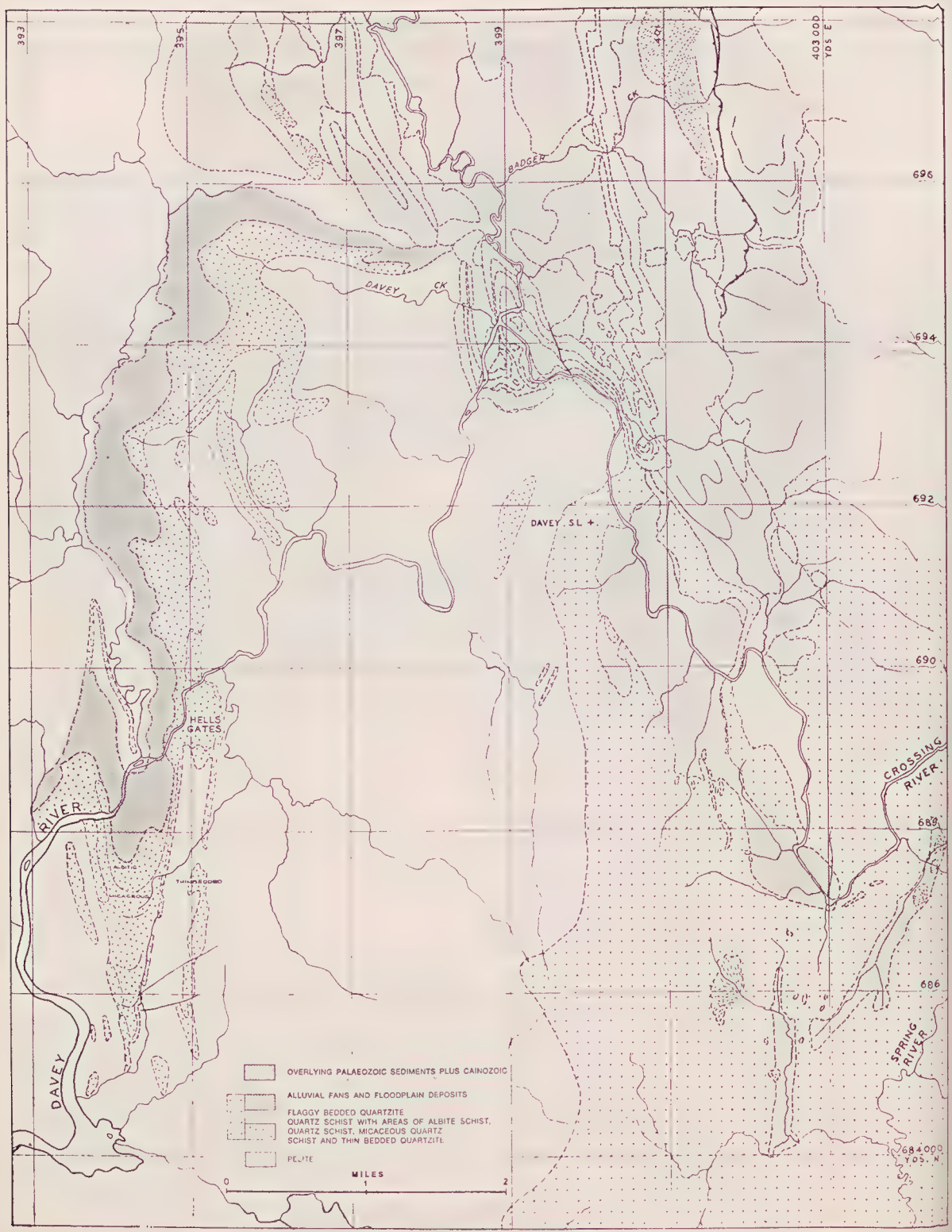

Fig. 1.—Geology of the Davey River Area.

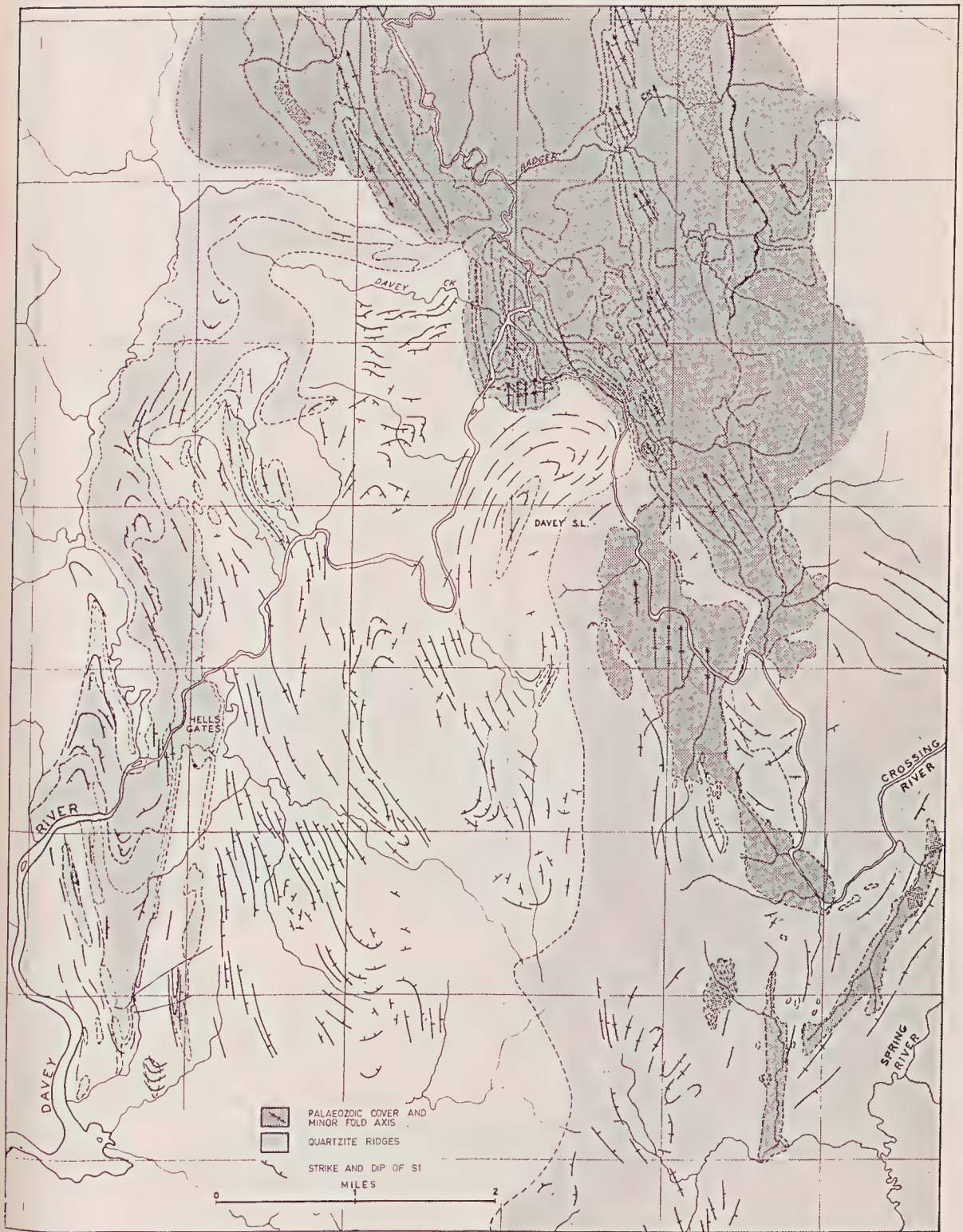

Fig. 2.—Structural Trend Map for the Transposition Surface, S1. Minor Fold Axes in the Overlying Palaeozoic Sediments are also shown.

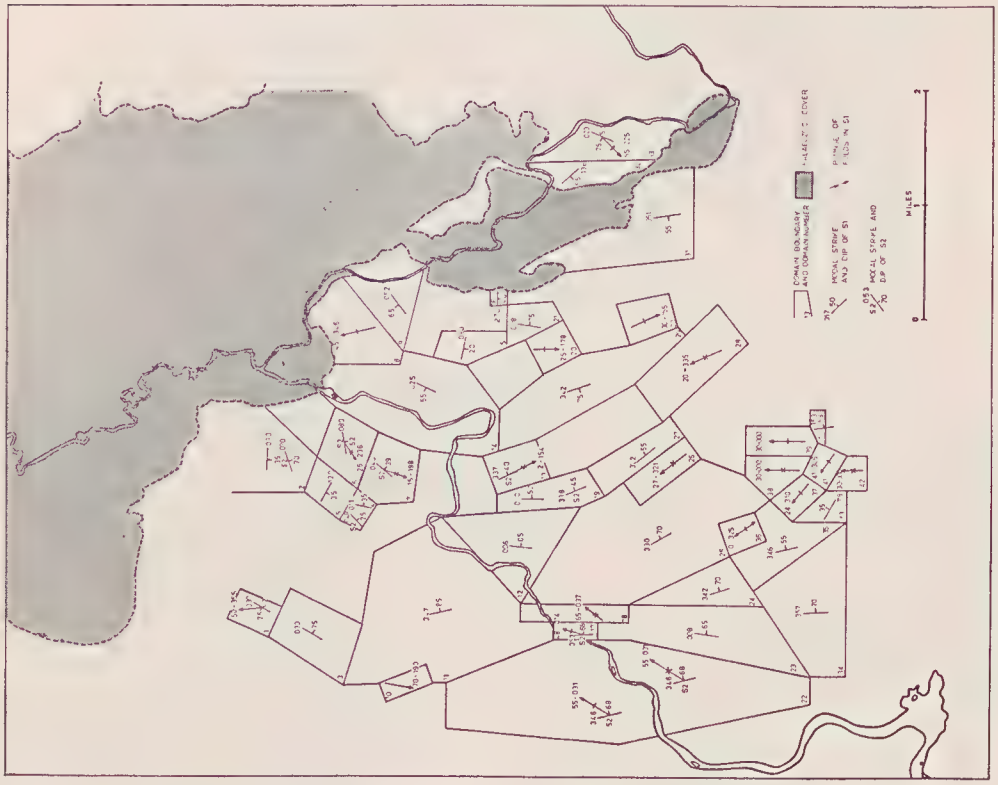

Fig 3.—(b) Statistically Homogeneous Domain for S1, the Predominant Foliation.

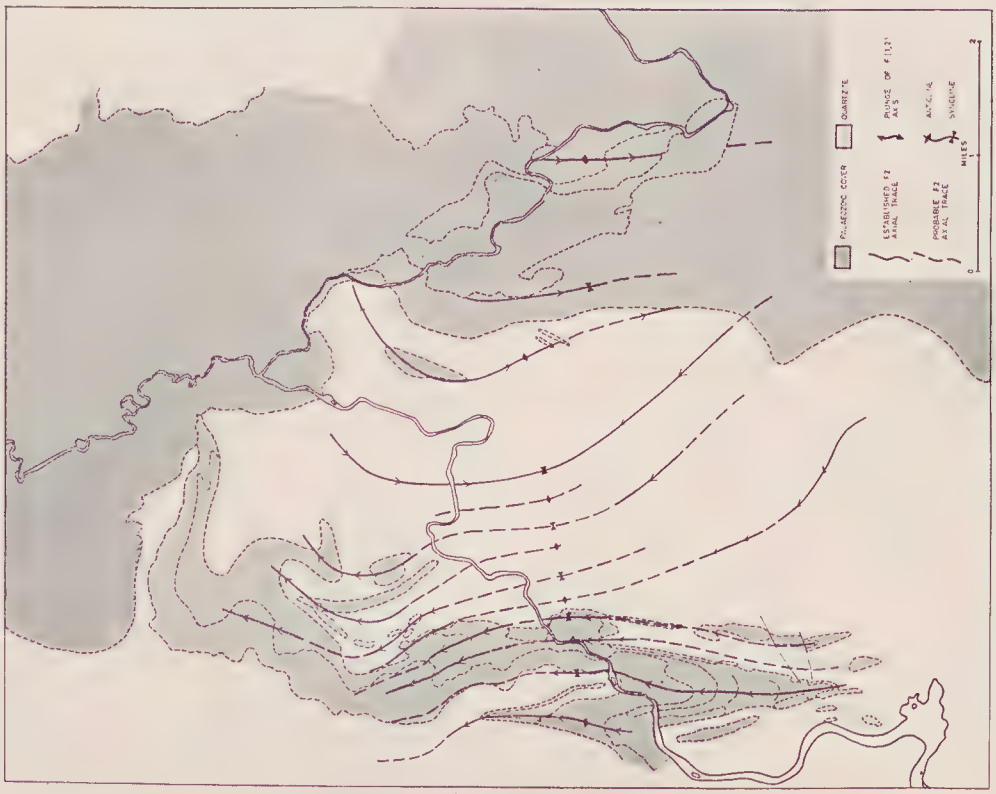

Fig. 3.—(a) Axial Traces of Major F2 Folds showing their effect on Lithological Boundaries. Arrows show the Direction of Plunge of the Axes.

principal foliations, S1 and S2, is strikingly similar at the two areas so that correlations on that basis are a justifiable first assumption. There are, however, differences in detail in the post-metamorphic structures.

STRUCTURE

Phase F1

The bedding foliation, S1, is defined by a preferred dimensional orientation of quartz grains together with a preferred dimensional and crystallographic orientation of mica flakes. Mesoscopically it is parallel to a lithological alternation or lamination which is a pronounced banding on the outcrop. In detail any lamina is lenticular and laminae split and bifurcate, which enables the banding to be distinguished from primary layering. On a regional scale S1 is parallel to the major lithological boundaries (as between quartzite and phyllite) but there are some regions where it is transgressive, notably in the Central-Eastern and North-Western areas of the maps. These transgressive regions probably represent relicts of F1 fold closures.

In the quartzite ridges of Hells Gates there are minor folds in bedding (SO) which have S1 as axial surface. The folds are usually isoclinal and occur interfolial to S1.

The history of events in F1 is obscure but it appears that several foliations and lineations were produced and folded.

Figure 4 is given as an example. The conical fold produced by the vertical axial surface, S2, folds both an earlier isoclinal fold and its axial surface. The refolded surface is a flattened quartz foliation, with a parallel mica foliation, and resembles S1. The axial surface of the refolded fold is marked by a slaty cleavage in the refolded hinge.

The upper diagram of figure 4 represents the folded surface (and corresponding lineations) after being flexurally unwound. It can be seen that the two lineations on this foliation form a different angle on either limb of the early fold, (the angles 'a' and 'b'): one is related to the early axis, while the other neither unwinds flexurally nor forms a plane through the whole structure. The history of this fold is obscure but indicates that there may be two textural events in F1 prior to the formation of S2.

Such early folds are relatively common in the quartzite ridges of Hells Gates, moreover, a specimen (1638)* of identical structure to the one described, was collected from the Gordon River damsite, some 40 miles due north; from an area described by C. Powell (1969).

Phase F2

The predominant structure of this phase is S2, a crenulation cleavage (Rickard, 1961) which occurs as axial-surface to folds in S1 (and rarely, S0). S2 is weakly developed in this area in comparison with other Tasmanian regions and away from major F2 closures may be entirely absent in many outcrops.

This foliation forms convergent cleavage fans about fold crests.

*Numbers refer to specimens in the collection of the School of Earth Sciences, Macquarie University.

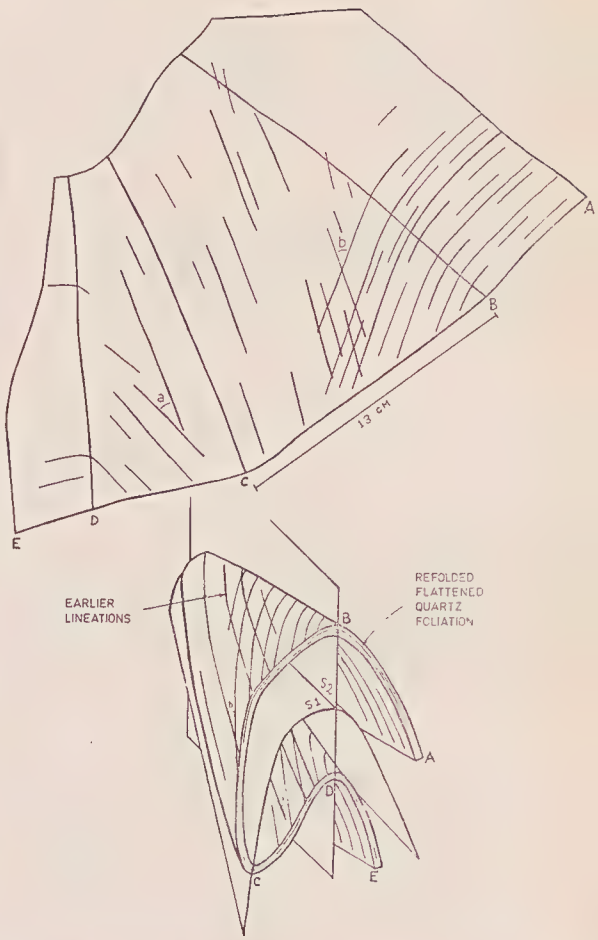

Fig. 4.—Refolded Isoclinal Fold Suggesting a Complex F1 History. The Upper Diagram Represents the Refolded Surface, and Associated Lineations, after Flexural Unwinding. The Angles a and b are Different. (Specimen 1627).

Figure 6 contains sketches of minor folds, showing how adjacent axes in an outcrop may at times vary in orientation by up to 90° with individual axes varying in plunge by up to 60°. These axes, though variable, all lie on the axial surface, and usually become more regular in the vicinity of major fold closures, where they parallel the major structure. Similar violations of Pumpelly's rule (1894) have been described by Gruner (1941), Hills (1951, p. 98) and Ramsay and Sturt (1963). Folds with this geometry were first noted by I. B. Jennings in the Upper Mersey Valley and are now known to be common in many areas, such as at Ulverstone and Cradle Mountain.

An example of typical set of folds in S1 is also shown in figure 6. The quartzite layers have largely concentric profiles, with the intermediate quartz schist layers behaving incompetently.

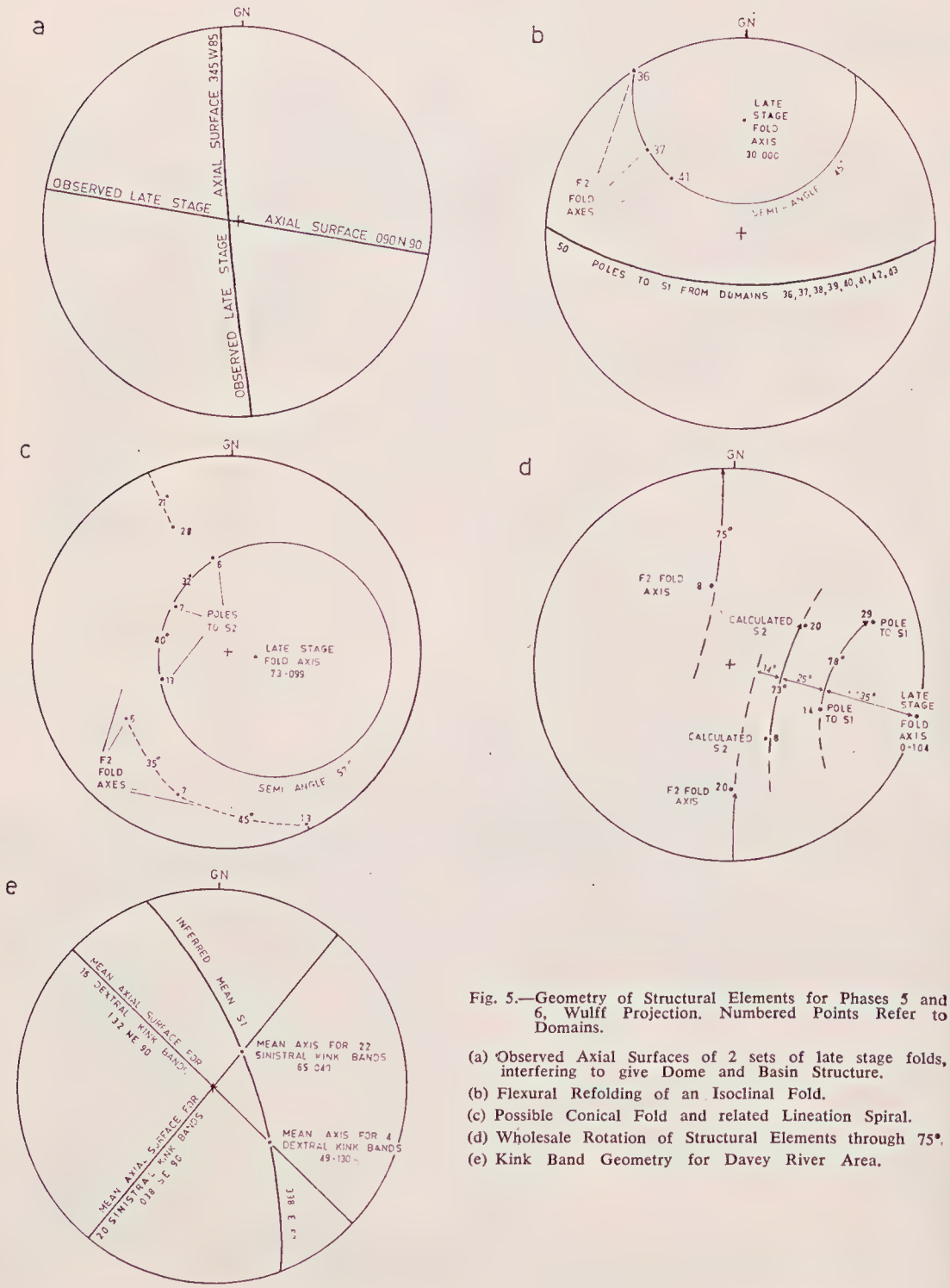

Fig. 5.—Geometry of Structural Elements for Phases 5 and 6, Wulff Projection. Numbered Points Refer to Domains.

(a) Observed Axial Surfaces of 2 sets of late stage folds, interfering to give Dome and Basin Structure.

(b) Flexural Refolding of an Isoclinal Fold.

(c) Possible Conical Fold and related Lineation Spiral.

(d) Wholesale Rotation of Structural Elements through 75°.

(e) Kink Band Geometry for Davey River Area.

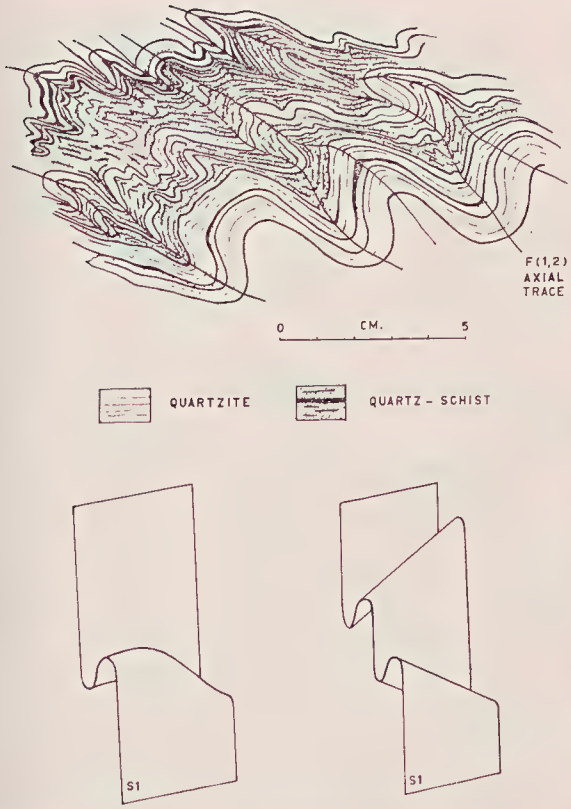

Fig. 6.—(a) Typical Profile of F2 Microfolds showing concentric Fold style of Quartzite Layers and Incompetent Behaviour of Quartz Schist Layers. Axial traces are shown, since the Foliation S2 is absent. (Specimen 1629).

(b) Diagrammatic Minor Folds in S1, showing different Modes of Plunge Variability for F2 Axes.

On a regional scale, isoclinal or near-isoclinal F2 folds with S2 as axial surface and S1 as the folded surface, are the predominant structure in the western part of the area. The closures are sometimes difficult to recognise due to poor outcrops but can be detected by analysis of the vergence (sense of closure) of minor folds.

The major axial traces are shown in figure 3a. The general trend is North-North-West through the southern half of the area, swinging around to East-West in the northern part. This strike swing is due to refolding of the F2 structure in later episodes of deformation (mainly F5). The large antiform-synform pair in the quartzite southeast of Hells Gates constitutes a large interfolial fold of quartzite in schist, with thickened and rounded hinge areas. Although it is still connected to its fold limb running to the north, this closure pair has some of the attributes of a major tectonic inclusion (tectonic fish). The adjacent folds in the schist are more highly attenuated.

Phase F3

A penetrative foliation named S3 crosses S2 at high angles in several places. It consists of a flat-quartz and parallel mica foliation superposed on S2. It occurs in several outcrops at Hells Gates but its areal extent is unknown. No folds have been recognised that can be attributed to this phase.

Phase F4

A fracture cleavage is widespread across the central part of the area. The cleavage is widely dispersed about a modal orientation of 071 S70. Mesoscopically it is non penetrative, occurring as wide-spaced fractures which are later than S2.

Phase F5

Deformation of this period resulted in large scale folding of F2 folds as shown by the structural domain and structural trend maps. Fold axes calculated from the domain map, are seen to lie very close to the same two planes which were observed in the field to be the axial surfaces of folds in S2. It is thought that two axial surfaces were impressed on the region, producing different fold axes in different areas, depending on the attitude of the layering in each area. Figure 5b refers to the lower central portion of the structural domain map and shows great circle rotation of poles to S1 and small circle rotation of F2 fold axes about the same axis. This is the expected pattern for an isoclinal fold which is flexurally refolded about a line in the axial surface.

Figure 5c refers to the central area of the structural domain map, and shows small circle rotation of poles to S2, forming a conical fold (or dome) and a non-describable rotation path for the F2 fold axes.

These axes lie by chance on a small circle, however, inspection of the structural domain map shows that the rotation path must be of the form indicated. Stauffer (1964) describes similar patterns for lineations on conical folds.

Figure 5d gives the orientation of structural elements for domains immediately east of those described by figure 5c and reveals small circle rotations of equal magnitude about a common axis, again suggesting conical folds. S2 for domains 8 and 20 was calculated from the strike of the axial surface and the attitude of the F2 axis.

In the region of the Davey Sugarloaf two sets of minor folds belonging to the F5 generation were seen to interfere to form a dome and basin structure. They are closely related in time, but probably not synchronous, and produced folds of similar size and style. The axial surfaces dip vertically, striking to the North and East, as can be seen from figure 5a, and have no foliation associated with them.

The major folds in the area, reconstructed from the structural trend and structural domain maps, are interpreted as late stage folds with axes lying on these observed surfaces, together with several areas of interference. These folds are arcs of cones (or domes) and therefore probably flexural in origin.

Phase F6

Kink bands are numerous in the Port Davey area, as is common for the Precambrian rocks of Tasmania. Spry (1963) and Powell (1969) have attributed these to the Palaeozoic in other areas. At the Davey River the kinks are very late structures and are minor in that no large scale folding is associated with them.

Figure 5e shows the geometry of kinks in S1.

This figure shows the average plane of S1 for the area as containing both sets of generated fold axes, but not containing the kinematic b-axis (vertical). The resulting fabric is an excellent example of that case described by Ramsay and Sturt (1963) whereby a triclinic fabric may be produced from movements with an orthorhomib symmetry being imposed on an asymmetrically inclined layering.

CONCLUSION

At the Davey River the predominant foliation is S1 which is usually parallel to regional lithological boundaries but in some areas is significantly divergent. S2 is less strongly developed than in areas described from the north of the State.

The principal episodes of deformation are F1, F2 and F5. F1 produced the transposition foliation, or 'bedding-foliation', S1, with minor isoclinal folds. F2 produced the crenulation-cleavage S2 and a set of major North-South trending folds which are tight to isoclinal with vertical axial surfaces. F5 resulted in two periods of superposed folding on two different trends, North-South and East-West. Where these trends interact, as at the Davey Sugarloaf, minor domes and basins occur. The forms of F5 folds are conical or related to conical. Episode 5 resulted in large scale flexural refolding of the early metamorphic layerings reminiscent of the Raglan Range structures of Gee (1963), so that events in F5 may be Palaeozoic.

REFERENCES

GEE, R. D., 1963—Structure and petrology of the Raglan Range, Tasmania. *Bull. Geol. Surv. Tas.*, V. **47.**

GRUNER, J. W., 1941—Geology of the Knife Lake area of Northeastern Minnesota. *Bull. Geol. Soc. Amer.*, **52,** 1577-1642.

HILLS, E. S., 1951—Outlines of Structural Geology Methuen.

POWELL, C. McA., 1969—Polyphase folding in Precambrian, Low-grade Metamorphic Rocks, Middle Gordon River, Southwestern Tasmania. *Pap. Roy. Soc. Tas.*, V. **103.**

PUMPELLY, R., *et alia.*, 1894—Geology of the Green Mountains in Massachusetts, *U.S. Geol. Surv. Mon.*, No. 23.

RAMSAY, D. M., and STURT, B. A., 1963—A Study of Fold Styles, their Associations and Symmetry Relationships, from Sy, North Norway. *Norsk Geologisk Tidsskrift,* Vol. **43,** No. 4.

RICKARD, M. J., 1961—A note on cleavages in crenulated Rocks. *Geol. Mag.,* Vol. **98.**

SPRY, A. H., 1963—Precambrian Rocks of Tasmania, part V, Petrology and Structure of the Frenchman's Cap area. *Pap. Roy. Soc. Tas.,* V. **97.**

SPRY, A. H., 1969—'Notes on Some Rocks in the Port Davey Area'. Unpublished report for the Hydro-Electric Commission.

STAUFFER, M. R., 1964—The Geometry of Conical Folds. *New Zealand J. Geol. Geophys.* V. **7.**

SOME NOTES ON THE LIFE AND TIMES OF CAPTAIN JAMES KELLY

(Read to Members of the Royal Society 7.7.1970)

by E. R. Pretyman

Perhaps one of the most interesting and active, though sometimes elusive, characters that could be chosen from the early inhabitants of Tasmania was, I think, James Kelly, as far as I can discover the first Australian born white boy to become a master mariner.

According to the inscription on the Kelly family tomb, which still stands in St David's Park, Hobart near the Salamanca Place entrance, James Kelly was born at Parramatta on 24 December, 1791. At the time of his birth Parramatta was the largest settlement in the newly established Colony of New South Wales. This fact came somewhat of a surprise to me during my research, but official figures show that even as late as October 1792, nearly five years from the time of the arrival of the first fleet, Parramatta had 1970 inhabitants while those at Sydney numbered 1170 only.

From Watkins Tench's account of the Colony it seems that Governor Phillip made many excursions in search of land more fertile than that at Sydney Cove. At last in April 1788 he found a spot some 18 miles from Sydney on the northern arm of Port Jackson, just above the head of navigation, which he, having a very fair knowledge of farming, considered a favourable area for agriculture. Instructions were issued, and so, on 2 November 1788, was planted the first settlement out of Sydney. It was named Rose Hill after George Rose, a Secretary to the British Treasury. Astride a small creek which still flows into the estuary at the northern arm, the township began to take shape; but Phillip learning that the aboriginals had another name for the locality decided to adopt that given by them in preference to Rose Hill—'thereby' as Dr Lang wrote in his history of New South Wales, 'exhibiting a degree of common sense, combined with correctness of taste which has been but seldom evinced by certain of his more ambitious successors'—and so at the celebration of King's Birthday on 4 June following this decision, Parramatta became the township's official name. At first it was a straggling village of one street about a mile long, on the borders of which were erected mud huts, tents and storehouses in allotments soon to be occupied by many convicts, for Phillip had conceived the idea of placing the industrious ones on the land with a promise that if they behaved well free grants would be made to them. And Tench wrote, 'Sydney has long been considered as only a depot for stores. It exhibits nothing but a few old scattered huts and some sterile gardens, cultivation of the ground is abandoned and all our strength transferred to Rose Hill (i.e. Parramatta).

The meaning of the aboriginal word 'Parramatta' has been accepted as 'the place where the eels sit down' and at the time of settlement and for many years afterwards the nearby estuary was famous for the number of eels caught from its muddy waters. It is not hard to imagine that as young Kelly grew he too would become interested, like many another boy, in fishing for eels. Then no doubt his interest would transfer to the small boats which began to appear, and soon he would seek an opportunity to board the slightly larger craft which were used to transport stores from Sydney to Parramatta.

We have been unable to gather really authentic information about his parents. J. E. Calder, one time Surveyor-General of Tasmania, who knew James Kelly personally, stated that they were of humble origin. Other statements repeat that his father was an army officer and his mother a Devereaux and a member of a family descended from French nobility. Much searching has not gained the evidence desired to support either theory, nor to prove that the date of his birth as inscribed on the tombstone is the correct one. However, it is not of his parents but of James Kelly that I am to speak.

There seems little doubt that he was a quick-witted child with, as Calder stated, a head full of brains. Very early in life, again according to Calder, he began to teach himself to read and write, and was soon learning something of the mysteries of arithmetic. Activities later in life go to prove that he was no dunce. One statement says that his mother always wrote to him in French, but unless one of these epistles can be discovered or other evidence produced, perhaps it would be wiser to leave the question an open one. Dumont D'Urville, the French explorer, in his *Voyages Around the World* does, however, mention with pleasure that he found many people living at Hobart Town who spoke well in the French language, and of course it is possible that James Kelly was one of these, but that came a little later.

The other story about Kelly's early years refers to the fact that he ran away to sea (even boys of our own day still do this or attempt to) but it is probable that he got no further than Sydney in one of the small boats returning there after carrying supplies to Parramatta. From a document still in existence it is found that at about the age of 12 he was, on 27 January 1804, apprenticed to a shipping firm for a term of five years and served under Captain Siddons. From 1807 onwards more definite glimpses of his life may be discovered, for it was in this year, according to statements he made to Commissioner Bigge, he sailed in the ship *King George* under Captain Siddons for the islands of Fiji to collect a cargo of sandalwood.

In the early part of the Nineteenth Century, Sandalwood was much used by the Chinese and the inhabitants of India, to make boxes, fans, and other articles as well as for incense and scents, and a considerable trade eventuated for shipowners in its collection. It is recorded that loss of life in trying to obtain this pleasantly scented wood was as great as the loss of life suffered by those sailing for whale oil, and there is little doubt that much of the Sandalwood trade was of a piratical nature. It may be remembered that John Williams the highly regarded member of the London Missionary Society lost his life largely due to native retaliation against white men who stole this wood from them, or maybe were involved in similar piracies. The people by whom James

Kelly was employed however, were thought to have used legitimate means to obtain their quota, and he stated that they had bartered iron, whales' and elephants' teeth and hardware in exchange for the wood which was brought by the natives to the water's edge. Despite the fact that the inhabitants of Fiji were well-known to be cannibals, young Kelly did venture ashore with other members of the crew and go inland. Because he had this experience he was later able to tell Commissioner Bigge that Sandalwood trees grew no larger than 18 inches in diameter, were not tall and generally flourished in ravines and in water runs protected from the sun. Often it took six months for the vessels to collect the quantity required. If taken to China £100 *per* ton could be obtained for the wood whereas in Sydney it brought from £50 to £70 only. The *Sydney Gazette* of 6 October 1810 records that Mr Reibey disposed of his shipment of Sandalwood at Whampoa for 16½ dollars a Pekul. Crews in these ventures received no more than £4 *per* man *per* month, but more often the pay was nearer £3. From this it will be gathered that with a quick turnround the profit to shipowners or charterers of those days could amount to a considerable sum.

During the year 1809 in the *Governor Bligh* under Captain Grono, who was later to become well-known for his shipbuilding, James Kelly made a long voyage on a sealing expedition. Then in April of 1810 he sailed in the *Marian* to India. Also during 1810 it was that Captain Hasselberg sailing south in the *Perseverance,* discovered Macquarie and Campbell Islands; soon rumours of the number of seals to be found there caused more than one shipowner quietly to fit out an expedition to obtain a share in the profitable industry. Among these was the firm of Kable and Underwood, owners of the *Campbell Macquarie,* a fine vessel of 248 tons. Young Kelly, because he had proved his ability to accept greater responsibilities even though not yet twenty-one years of age, was under Captain Siddons appointed her chief officer. On 23 March 1812 the *Campbell Macquarie* sailed from Sydney for Macquarie Island and had collected only some 200 skins when she was compelled to seek shelter from a severe storm near the island. Caught in a sudden squall on 10 June she was driven ashore and soon went to pieces. Her crew (12 Europeans and 30 Lascars) was able to get ashore and salvaged three suits of her sails but the 2000 skins, 36 tons of salt, 118 tons of coal and most of the stores she carried were lost. Hasselberg two years earlier had found wreckage of an unknown vessel there but the *Campbell Macquarie* has the doubtful honour of being the first vessel known by name to be wrecked on Macquarie Island. About the time of this disastrous affair it so happened that the *Perseverance,* the vessel from which the island had been discovered, was again in these waters. Her commander (not Hasselbergdel, for he had been drowned off Campbell Islands on 4 November 1810), gave all the assistance within his power to the crew of the ill-fated *Campbell Macquarie* but was not able to take more than two or three survivors on board. James Kelly was one of these. The others were compelled to remain until rescued by a special vessel sent down from Sydney. The *Perseverance* meanwhile continued sealing. It was October before the Coast of New South Wales was reached and even then bad weather prevented entry into Port Jackson. They made for Broken Bay and reached that Harbour on the 29th. Kelly landed as soon as he was able and hurriedly made his way overland to Sydney. It is possible that he was to give first-hand information to the owners of the fate of the *Campbell Macquarie* but it is more probable that he was anxious to report his own safety to his sweetheart, for he was then about to undertake the further responsibility of matrimony. The Banns were published and within three weeks, on 17th November, 1812, to be precise, he was married to Elizabeth Griffiths, a young lass of 17 years. He was almost 21. The ceremony was performed by the Rev. William Cowper at St Philip's Church of England, Sydney, Kelly being described as a bachelor whose occupation was that of mariner; the witnesses who signed the register were Thomas Corbitt (or Cubitt) and Mary Griffiths, the latter apparently the bride's sister.

Having now a wife to support there is little doubt that he gladly accepted an appointment as Master of the *Brothers,* a sealing vessel, and in her as Captain Kelly, with a crew of 10, he left Sydney Cove during the first week of January 1813 to go on a sealing venture in Bass Strait. On the way down they met bad weather, lost the vessel's foregaff and decided to run for King Island. Here they cut a new spar and effected the necessary repairs. They then sailed for Western Port where some 750 seal skins were collected. All the best known rocks or other likely spots for seal rookeries in the area were in turn visited and after having taken and salted some 7090 skins during the four months they were out the *Brothers* reached Sydney again on 31st May. It is practically certain that this was the first trip Kelly had had in Tasmanian waters as a master of a vessel, and the proceeds of the voyage could be considered extremely satisfactory.

Here perhaps I might mention that the first reference to an attempt at sealing in Australasian waters I have been able to discover is in a letter to Secretary Stephens written by Governor Phillip on 18 November 1791, strangely enough within a month of Kelly's birth. In this letter Phillip stated that the *Mary Ann* and the *Matilda* had been driven by bad weather from the south ward where they had gone in search of seals but had not seen any fish. The first worthwhile catch recorded is the one at Dusky Sound, New Zealand. Here a gang of 11 men had been landed by William Raven, master of the *Britannia* and at the end of 12 months had collected 4500 skins. The first really great sealing ground in Australasia was in Bass Strait where the industry was commenced by Captain Bishop of the *Nautilus.* The *Nautilus* you may remember for a time accompanied Bass and Flinders in the *Norfolk* when the Strait was discovered. Bishop with his men landed at Kent Bay on Cape Barren Island, built huts, formed gardens and not only grew the first potatoes in the Territory but were actually the first white men to make a settlement within the limits of what we now know as Tasmania. By 1802 something over 200 men were employed in various sealing gangs on Cape Barren, King and other islands in the Strait and the practical extermination of the seal had begun.

But to return to Captain Kelly. His next venture was more hazardous than that in the *Brothers* and is mentioned because during it he probably made his first visit to Hobart Town. In September 1813, he left Sydney in

command of the *Mary and Sally,* a brig of 130 tons. Records indicate that she belonged to William Collins, first pilot, harbourmaster or port officer at the Derwent, and was being sent by him to Macquarie Island for oil and seal skins. Macquarie Island lies some 850 miles south-east of Tasmania and is subject to severe batterings by sudden storms, during one of which as previously mentioned Kelly had been caught when chief officer of the *Campbell Macquarie;* this time he would have been well prepared, and despite the heavy weather again encountered, the *Mary and Sally* reached the protection of the island after a voyage of 14 days. Men were put ashore with stores for themselves, a good supply of salt, for salt was indispensable for curing skins of fur-bearing seals, coopers' gear and hoops and timber for casks or barrels. Weather conditions were not favourable and Kelly on numerous occasions had to change his anchorage, in one case losing an anchor. On 28 January, he put his people on a reduced ration of one pound of 'bread' (biscuit) *per* man *per* week. It was 19 February before the return voyage was begun. Three weeks later Hobart Town was reached. It seems that this snug little town, at the foot of the mount we now call Wellington, and its proximity to sealing and whaling areas so appealed to him that he mentally decided to make it the site of his future home. For two years, however, he accepted employment from Dr Birch and in the recently completed *Henrietta Packet* sailed for him between Sydney and Hobart Town and other colonial ports.

The year 1815 saw Kelly building his famous 'Rock House. Some may remember the quaint stone and brick building perched on the rock bank overlooking the Hobart Rivulet near the intersection of Campbell and Collins Streets. The outlet from the one time car park to Campbell Street between the hospital buildings and the rivulet would be near where the building once stood. Before his wife and family, then living at 22 Cumberland Street, The Rocks, Sydney, came to settle permanently in Hobart Town, James Kelly took part in what is his best known exploit, namely the circumnavigation of Tasmania in an open whale boat. There are three known accounts of this venture, one in Kelly's handwriting held by the Royal Society of Tasmania, another in the Mitchell Library, Sydney, not written but believed signed by him, and the third in London with a letter dated 16 April 1816 from T. W. Birch to the Secretary of State for the Colonies.

Before giving some details of this epic voyage perhaps possible reasons for its undertaking might be suggested. It will be remembered that Matthew Flinders and George Bass in 1798 in the *Norfolk* had proved the existence of Bass Strait and sailed completely round Tasmania, but because of bad weather and poor visibility were unable to sail close enough to the south-western portion of the island to obtain very accurate information. That area was still very much 'terra incognita' up to 1815. After settlement at the Derwent various short expeditions only had been made in that direction. On one of these the Rev. Robert Knopwood records that he with others had visited the Huon River and on the way had discovered a new and curious wood. Because it was first found in this locality it came to be known as Huon Pine. Its qualities and value were soon recognized. A little later Surveyor Oxley came upon a great quantity of the pine piled up on Huon Island and he made the suggestion that it had come down the river during some violent flood; others thought it had come from the West Coast. Despite its usefulness no effort appears to have then been made to discover the locality from which it had come. An enterprising resident of New Norfolk decided to explore the South and West Coasts. *The Sydney Gazette* published the following report:

> 'On 21st November, 1815 the *Geordy* Mr McCarthy, owner and master, sailed from Hobart Town for the purpose of narrowly examining the South West of the Island of Van Diemen, intending as our correspondent informs us to run through Storm Bay Passage [now known to us as D'Entrecasteaux Channel] past the South Cape and bestow particular attention on the Coast facing the Island of De Witt and thence round Cape St Vincent, inspecting every Bay and Inlet that shall present itself on that part of the Coast'.

By his journal entry for 22 November Knopwood confirmed that McCarthy had actually sailed on the venture. Then on 4 December, he wrote that Mr McCarthy had 'come up in his boat having lost his schooner off the South Cape. A gale came on and she parted both her cables and he ran her on shore'. Questions immediately arise. How far did McCarthy go? Did he find any pine? And had James Kelly gone with him? For eight or 12 days days later, according to which log book record is accepted, James Kelly set out on his remarkable voyage of circumnavigation in a whale boat. One cannot help wondering whether McCarthy's attempt had stirred Kelly into action or whether McCarthy had attempted to forestall a projected expedition about to be made by Kelly and/or Birch. There is no newspaper notice until 2 March 1816 when the *Sydney Gazette* commented that 'a very fine harbour has lately been discovered by Mr Kelly in the *Henrietta Packet*. . . .' Comments about the voyage appeared in the *Hobart Town Gazette* on 15 June and as this paper had only just commenced publication and the information a little late we are dependent on the details written by Kelly himself. From an examination of his journal held by the Royal Society of Tasmania it becomes apparent that it could not have been written during the circumnavigation voyage. It is reasonably neat though at times the colour of the ink varies. Comments about events subsequent to the voyage indicate that it was written some 10 or more years after his return. The *Hobart Town Courier* in 1854 published a series of articles headed 'some unrecorded passages in the history of Tasmania from a very old stager' and these appear to have been copied from the Journal now held by the Royal Society. J. E. Calder, the one time Surveyor-General, considered the articles important and asked for them to be reprinted in Parliamentary Papers. This was done in 1881. Then in 1920 the Council of The Royal Society decided that because of their historical interest the actual records made by Kelly should be published in the Society's own *Papers and Proceedings,* and this was done in December. The copy of the Journal held by the Mitchell Library is somewhat similar to the third account of the voyage enclosed with the letter from Dr Birch to the Secretary of State for the Colonies.

> The Royal Society's copy of Kelly's Journal begins: On 12th December 1815 James Kelly sailed from Hobart Town in a small sized open five oared whaleboat to examine the then unknown West Coast of Van D. Land accompanied by the following named four men as crew: John Griffiths, a native of the Colony, George Briggs, ditto, William Jones, Englishman, Thomas Toombs, ditto.'

He then goes on to relate that on attempting to land at Recherche Bay next evening they were met by a large body of natives who gave them a volley of stones and spears and in consequence the boat party was obliged to retreat to the other side of the Bay. Next day to the North of De Witt Islands they were again met by a large group of aboriginals but this time given a friendly reception. Presents of sugar and biscuits were given them, but Kelly comments disgustedly on the fact that these people seemed to prefer vermin taken from their heads and beards to eating the biscuits and sugar. Five days later he recorded that he entered a large inlet 'which was named Port Davey in honour of the then Lieutenant Governor'. The word 'then' indicates that the account was written after the retirement of Davey at least. Time was spent preparing two rods of rich ground in which seeds were sown and the locality consequently named Garden Point. Sounding and sketching the extent of the harbour and in collecting a quantity of wild fowl, eels and fish took another three days. The eastern arm of the harbour was named Bathurst in honour of Lord Bathurst, a point on the inner west was named Point Lucy after Lieutenant-Governor Davey's daughter, and so on. On 22 December they hauled up in a snug cove near High Rocky Point and here remained weatherbound for three days. On Christmas Day he wrote:

> 'This day we had a glorious feed for dinner two black swans, one roasted (stuck up) the other a sea pie a three decker in the large iron pot a first rate Christmas dinner on the West Coast of, Van Diemen's Land—after dinner we named The Cove Christmas Cove by throwing a glass of brandy into the salt water and three hearty cheers for the ocasione.'

In his book on Western Tasmania Charles Whitham says: 'This is the most extraordinary thing that has ever occurred on the West Coast. As Kelly was the first so also was he the last to throw away good liquor. The pioneers I have met knew only one way to dispose of it.' At midday on 27 Kelly passed Point Hibbs (so named by Flinders after the master of the sloop *Norfolk*) and the followng day under cover of a pall of thick smoke entered the narrows of an inlet. During the afternoon the smoke cleared a little and the explorers found themselves 'in a large sheet of water near a small island.' Next morning the name 'Elizabeth' was given the island in honour of Mrs Gordon, wife of James Gordon of Pittwater, and the harbour called Macquarie in honour of the *then* Governor of New South Wales. (Macquarie's administration, you will recall, ceased in December 1821). On the mainland almost opposite Elizabeth Island a fresh supply of fat black swans was obtained and the four remaining from those they had brought from Port Davey were released. The area was then called Liberty Point. [This name had nothing to do with convicts later in the vicinity as is sometimes suggested.] An island about 25 miles up the harbour was named Sarah in honour of Mrs Birch, the wife of Thomas William Birch, Kelly's employer. This island later became headquarters for the penal station and was for many years generally known as Settlement Island. Modern maps have the original name.

Opposite the southern end of the largest of the Hunter Islands it was decided to land to enable the boat's crew to take a much needed rest and Kelly wrote:

> 'We had just got a fire lighted when we saw a large body of natives, at least fifty . . . standing at the edge of the bush . . . they were all armed with spears and waddies . . . we brought the arms from the boat and put ourselves in a state of defence near the fire they began to advance slowly towards us we held up our pieces and made signs . . . not to come any closer they held up their spears in return with loud-laughing and jeering at us as if they thought we were afraid of them . . . all of a sudden they laid down their spears and waddies . . . and holding up both their hands . . . at the same time making signs to us to lay down our arms which we did . . . they then began to come to us one by one . . . we kept a good lookout that they had no spears between their toes . . . twenty-two came to the fire (we made signs that no more should come) upon that being understood two more came from the bush together one of them seemed to be a chief a stout good looking man about six feet high 30 years of age the other an old man about six feet seven inches high with scarcely 'a bit of flesh' on his bones. When the chief came he ordered them all to sit down . . . the old man to dance and sing as if to amuse us which he did making ugly faces and putting himself into most singular attitudes. While the old man was engaged in his dancing and singing we found out it was only to take our attention off what the chief and his men were doing he ordered them to gather pebble stones about the size of hens eggs and put them between their legs where they sat for the purpose as we supposed to make an attack on us . . . our men began to get alarmed . . . we planned to give them a few swans . . . Briggs brought two swans from the boat one under each arm. When the chief saw them he rushed at Briggs to take the swans from him but did not succeed he then ordered his men to give us a volley of stones . . . and a severe volley it was. I had a pair of large dueling pistols in my coat pocket loaded . . . and seeing there was no alternative I fired one amongst them which dispersed them the other I fired after them . . . the chief and his men run into the bush and was quickly out of sight . . . after they had all ran away we found the 6 feet 7 inch dancing gentleman laying on his back on the ground we thought of course he was dead but on turning him over to examine his wounds found he had not a blemish on him his pulse was going at 130 . . . We then set him on his feet to see if he could walk he opened his eyes and trembled very much we led him a few steps . . . he stood up straight looked around him and took one jump towards the bush the next leap he was out of sight . . . we measured the first jump the old man took it was exactly 11 yards but the second one must have been more this was more like the jump of a kangaroo than a man.'

As a matter of interest I can add that in **Wild Life** for 1951 it is stated that forty-two feet or fourteen yards had been covered by a forester kangaroo. Olympic long jump record still stands at 26¾ feet or nine yards so that fear must have helped the old aboriginal make a jump of eleven yards if Kelly's account can be accepted.

Not long after this incident the boat party sailed from Circular Head for Port Dalrymple and George Town, where no sooner had they landed than they were placed under arrest. The military guard had mistaken them for bushrangers thought to be in the vicinity. Evidence of identity proving satisfactory they were released and Kelly stated that the Commandant then invited him 'to come up to the Government Cottage and accept of a knife and fork and a bed at my quarters while you remain at George Town,' and to his Sergeant said 'let his men live with the soldiers give them plenty to eat and grog but don't let them get drunk.'

On 12 January the whaleboat voyage was continued. At noon the following day he records that they landed at Ringarooma Point. Because I personally think that the name Ringarooma was not used until after the wreck of the *Sally* nearby in 1826 it is my belief that the journal from which I have quoted was not completed before that year, and was probably written up from a rough log book, or that Kelly was drawing on his memory. At Ringarooma Point as he called it they were again greeted by aborigines whose leader wished him to assist in a raid upon a tribe near Eddystone Point. To avoid this Kelly offered to take his boat to a nearby island to ask sealers to take part. This offer was accepted and they were allowed to leave but Kelly had no intention of keeping his promise for he could see that without some such ruse he and his crew would never have escaped. On 14 he reached Eddystone Point where for a time contact with the natives known to be in the vicinity was delayed because of the belief that bushrangers were with them. Some sealing was done but the seals becoming shy a visit to the aboriginals for fresh water was suggested. On hearing that the seals were scarce Tolobunganah the local chief suggested that they should take some of the women of his tribe to assist and six were detailed to go. Kelly then describes the 'singular mode' they followed. After a stay of nine days during which some 172 seal skins and 246 kangaroo skins were collected, the whole said to be worth £180 in Hobart Town, Kelly's party left to complete his voyage. At noon on 30 January they passed Iron Pot Island and reached Hobart Town at four p.m. after a voyage of discovery lasting forty-nine days, 'without meeting with any accident or danger further than what was contained in the Journal,' as he put it. The report of the circumnavigation attached to Birch's letter to the Secretary of State, referred to earlier, gives a reason for the voyage being made in a whaleboat. It reads:

> 'We layed the schooner *Henrietta* up to make the first attempt in a whaleboat, we well knowing what we must expect if a gale came on from the westward and being then on a most dangerous lee-shore—the loss of the schooner and all hands, but in a boat might get a chance and save our lives by beaching her or running under the lee of an island where a vessel could not go'.

The record then follows with much less detail the routine given in the account held by the Royal Society but with variations in the dates of discoveries and naming of features. The most noticeable disagreement between the accounts is the time taken to make the voyage. Birch's account said it took thirty-three days while Kelly's journal records forty-nine. For the expense Birch incurred in fitting out the expedition the Government compensated him by granting the sole right for twelve months to take timber from the two harbours discovered. Kelly later received a land grant of one hundred acres on Bruny Island.

The next outstanding event for Kelly no doubt was 'settling in' his wife and two daughters at 'Rock House', late in 1816. The family lived here for eight years the first three of which Kelly spent as master of the *Sophia* sailing on further trips to the West Coast for pine and other timbers and plying between ports in Van Diemen's Land and New South Wales, and making a sealing voyage to New Zealand. Considerable importance has been given to the records of this sealing venture, and the discovery of the *Sophia's* original logbook would even today be an event of great interest to archaeologists and anthropologists, for up to the present they have depended on newspaper accounts of an incident in which Kelly was involved. When reading a paper before the Otago Institute on 11 June 1895 Mr A. Hamilton stated that he thought the published account of this incident which happened near Otago had been written in a guarded manner. He had therefore made many enquiries of old residents and finally had written to Mr Taylor, Librarian of the Public Library Hobart, for confirmation of Kelly's statement. In reply Mr Taylor had sent him copies of the original newspaper article, had confirmed the dates of the *Sophia's* clearance for New Zealand and of her return, adding that the vessel and her owners were well known and he had every reason to believe the account was a correct one. The article referred to by both Hamilton and Taylor appeared in the *Hobart Town Courier* on 12 April, 1858. It was headed 'Adventure at Otago forty years ago', and begins:

> 'The *Old Stager* has handed us a narrative of events that happened to him on the South East Coast of New Zealand, part of which was published on his return to port in Bent's *Hobart Town Gazette and Southern Reporter* of 28 March 1818. Full details of the narrative were not furnished but now for the first time are completed from his 'ancient log.'

The old stager was of course James Kelly and the ancient log could possibly have been that of the *Sophia*. The *Sophia* it seems had sailed from Hobart Town on 12 November 1817 on a sealing voyage, on 11 December had anchored at Port Daniel (later known as Otago) and Kelly with a boat's crew had gone ashore to barter for potatoes. They met with a friendly reception, in part attributed to the fact that one of their number—William Tucker—was remembered from a previous visit. The Maoris called Tucker 'Wioree' which in their language would I think mean 'tail' possibly from the fact that he was wearing an old time sailor's pigtail. A similar reception was given them the following day and Kelly met and talked to a lascar who offered assistance in bartering the potatoes. Many natives meanwhile had assembled near the house of the

chief from whom the potatoes were to be obtained. Suddenly there was a vicious war cry yell or call and the Maoris attacked. Kelly, John Griffiths and a man named Viole were thrown to the ground. Tucker, Wallon and Dutton managed to break through and ran for the boat, when thinking it impossible for the others to have escaped, launched it. Meanwhile Kelly was engaged in a dreadful contest but by good fortune having a billhook with him swung it to such purpose as to enable him to make his ecape. He reached the boat and was dragged through the surf. Tucker still impressed with the friendly reception he had received remained on the beach but was soon cut down. Griffiths and Viole were not seen again. Kelly and his three men on reaching the *Sophia* found an estimated one hundred and fifty Maoris on board. Though appearing to be friendly they were apparently planning to take the vessel. Kelly called his men to quarters and formed a square under the main boom. He ordered his men to draw their sealing knives, each man carried two. This had the desired effect the Maoris fled, some jumped overboard were caught in the tide rip and drowned, some were wounded and others got ashore. Their chief was captured and held on board. That night a careful watch was kept. Early next morning the chief was taken on deck. When the Maoris on shore saw him there was great rejoicing. He called to them it was thought to bring a large canoe load of potatoes to pay for his liberation. Two men paddled the canoe to the brig. It was then seen to be full of men, nearly forty of them covered by mats. Those attempting to board the brig were shot down, and the attack was abandoned. Next morning Maoris were seen to be launching their war canoes and Kelly thought it better to stop them if possible. Two boats were manned, arms and ammunition taken and rowed close to where the canoes were lying. On the boats approaching the shore, the Maoris fled over the bank. The crew from one of the *Sophia's* boats landed, while those in the other kept them covered. The shore party then sawed each canoe into three sections. There were forty two canoes, large and small and all were destroyed, many pieces being taken to the brig for firewood. Kelly decided to land and fire the Maoris' town. He recorded that it was 26 December and a fine clear summer's day with a fresh hot wind blowing from the North-West. Nine men were put ashore and the two boats kept afloat. 'On our approach' he wrote, 'the natives ran to the rising hills and left us in full possession of the town. This town consisted of about six hundred fine houses and perhaps a finer town was never seen in any part of New Zealand. The fire was lighted at the weather end and in about four hours the beautful city of Otago, as we called it, was laid in a heap of ashes.' Kelly's report of the destruction of this town is still of much interest to present day archaeologists. Although seemingly exaggerated it gives them a firm date to use in connection with excavations for pre-European Maori civilization. They believe that if the original log-book of the *Sophia* could be found it would give them an exact description of the site of the village destroyed.

Not long after his return to Hobart Town, on 8 April 1818 to be precise, some convicts boarded and escaped from the Derwent in the Government launch. Birch, Kelly's employer, immediately offered his vessel with Kelly in charge, to assist in capturing the pirates. Twelve days were spent with an armed detachment searching the East Coast. Eventually the absconding men were caught at Port Sorell on the North Coast and Kelly had the doubtful pleasure on 24 May of taking them in the *Sophia* to Sydney for sentence. His next adventure followed very quickly. The *Sydney Gazette* of 20 June reported that a daring attempt had been made by a set of ruffians in a boat to board and carry off the *Sophia* lying in Sydney Cove. It seems that for some time previously, merchants of Sydney, shipowners and others had suffered from similar attacks by piratically minded bands of marauders. Information had reached the police that an effort was to be made to capture Kelly's vessel when next she came to port. Soon after her arrival a story was allowed to circulate that Kelly was about to go on a visit to Parramatta. Police were alerted on shore and a close lookout kept by the crew of the *Sophia*. Very early in the morning the expected attempt began. Kelly, having returned secretly directed proceedings from the brig. A brisk discharge of musketry indicated that the would be pirates had reached the vessel, gave warning to the waiting party on shore and wounded some of the attackers. A well-manned boat under the direction of the Governor's coxswain set out to capture the desperadoes, but they escaped. A detailed description of the affair in the *Sydney Gazette* was followed by the comment:

> 'We hold to public view and admiration the bold spirited faithful conduct of Captain Kelly which cannot be too highly commended or appreciated and the masters and crews of the Colonial Shipping are called on by every principle of duty to show an equal zeal in defence of the persons and property entrusted to their charge . . . it is with no little satisfaction we understand that it is in contemplation with the merchants and shipowners of Sydney to present Captain Kelly with a handsome piece of plate inscribed with the record of his manly and successful exertions in repelling a strong and desperate party of sanguinary pirates, and we hope a liberal consideration will also be extended to the meritorious crew.'

Trouble in Hobart Town with the increasing number of convicts arriving caused Lieutenant-Governor Sorell to give serious consideration to the establishment of a small settlement in which the worst of them could be detained. He appointed Thomas Florance to make a survey of Macquarie Harbour and engaged Birch's Brig *Sophia* to take him round. Sorell of course knew that her Master James Kelly could and would give valuable assistance by pointing out channels, landing places, obstacles to shipping, indicate where best stands of timber would be found and also advise on the treatment of some aboriginals living in the area. Sorell had a very high opinion of Kelly's seamanship as well as his knowledge of the coast and so in April 1819 when the appointment of a harbourmaster was under discussion Kelly's name was mentioned. When Sorell informed Macquarie that such an office was necessary to combat smuggling and the seizure of small vessels he pointed out that Kelly's zeal, steadiness and good character were already known to the Governor-in-Chief himself, who on 15 May readily confirmed the appointment. For twelve years Kelly then held the dual position of harbourmaster and joint pilot at Hobart Town. Near the end of this period a steady increase in shipping entering the port and the frequent need to

call upon the water bailiff to act as pilot caused Governor Arthur to review the position. He consulted Kelly and they both agreed that the duties of one or other of his offices should be transferred. Kelly decided to relinquish harbourmaster responsibilities. Then shortly afterwards, possibly because of the death of his wife following the birth of a child, he asked to be relieved of the duties of pilot, as well.

During his term as harbourmaster and for a time afterwards his affairs had prospered and he enjoyed a certain amount of publicity. He owned several vessels, reaped a harvest of oil from whaling and sealing expeditions, increased agricultural areas and cattle raising interests on Bruny Island and was able to afford the expense of having two of his boys educated at the Bath Grammar School in England. He held a seat in pew number ten at St David's Church, Hobart, contributed to funds being raised for the erection of St George's Church on Battery Point, became a shareholder in the organization formed for the purpose of erecting a theatre in Campbell Street and was elected one of the first directors of the Derwent and Tamar Fire and Life Insurance Company at the inaugural meeting held in the Freemasons' Hotel on 28 October 1838. So his life was both active and his interests varied.

In addition to port duties he had been called upon to assist in the establishment of the Penal Settlement at Macquarie Harbour by taking the Commandant, Lieutenant Cuthbertson, his staff and a number of convicts round in the *Sophia*. In 1825 in his whaleboat he took Lieutenant Murdoch to inspect the proposed site for a secondary penal station on Maria Island. With four others in 1826 he formed the Derwent Whaling Club for the purpose of sharing in whaling ventures and rewarding the person who gave them first news of a whale entering the river. The profits made by this club were divided into seven parts, one part went to each member, one part was devoted to charities and the remaining part was presented to a youth born in the Colony who displayed the greatest expertness as a whaleboat headsman. In 1828 he assisted in the establishment of a military station at Waterloo Point near Swansea and in 1838 when Lieutenant-Governor Sir John Franklin suggested that a carnival should be held to commemorate the discovery of Van Diemen's Land by Tasman, James Kelly was one of the first members of the committee appointed to organize the function soon to be known as the Anniversary Regatta, a carnival which as you know, even after the lapse of one hundred and 30 odd years, is still recognized as one of the most popular aquatic events in the Southern Hemisphere. On the one occasion when Vice-Regal patronage was withheld because of some unseemly behaviour by certain people on Pavilion Point, James Kelly was elected Chairman and the Regatta was held at and from Chaffey's Point, Sandy Bay, now well known as Wrest Point.

There is only one known, rather poor portrait or sketch of James Kelly which is now held by the Queen Victoria Museum in Launceston, but several word pictures enable us to visualize something of his personality. Widowson, in his *Present State of Van Diemen's Land* published in 1829, when referring to their vessel's arrival at the entrance of the Derwent, commented on Pilot Kelly's size and his unequivocal appetite.

Calder said 'Kelly was one of the most active, daring and resolute of the old class of Tasmanians—a class of men who as colonists had no superior'.

And in the *Bulletin* in 1927 a contributor 'M.H.' wrote:

> 'My grandparents lived next door to Captain Kelly, Hobart's first harbourmaster. I have a vicarious mental picture of the old captain, jovial, portly and autocratic, back from one of his successful sealing or whaling expeditions, titivating before a mirror in preparation for some social fray whilst his dutiful daughters fluttered round him. He bulked large in the public eye physically, no less than socially, and once won a bet that his trousers would hold five bushels of wheat.'

During the 1830s Kelly's good fortune began to deteriorate, perhaps due to his own actions as well to circumstances beyond his control. First in 1831 he lost his wife. Then in 1834 his rather fine little vessel the *Australian* was wrecked on Bruny Island and he lost the proceeds of what was a favourable whaling season. In 1839 he became involved in an affair which led to court action and the payment of somewhat heavy damages. In 1841 his eldest son James Bruni Kelly while on an expedition died from the effects of a blow from a whale. In 1842 Thomas, his third son, was drowned when the boat he was in on the Derwent capsized. During the same year Kelly was compelled to assign the greater part of his real estate to creditors. Then he was severely hit by the commercial depression during the years 1842 to 1846 and his remaining assets soon melted away.

During celebrations which followed the launching of the *Lady Emma* from the shipbuilding yards of Degraves in December 1848 a Mr Lewis proposed the toast 'Captain Kelly, the father and founder of whaling in Tasmania' and added that the captain had lost his all in the pursuit and was now a poor man; and while he had expended his means in establishing the fishery others were making fortunes by just following the example he had set them.

It was a sorry statement to have to make, for the early activities of the captain had given promise of ease and comfort in his old age, and although he attempted several times to re-enter the whaling business, his circumstances did not improve and he was glad to accept employment in some of the humble tasks offered by port authorities.

And so, on 20 April, 1859 as he walked in Argyle Street, Hobart, with a Mr Holland, to arrange for the funeral of a relative, he suddenly stopped near the Jewish Synagogue, exclaimed 'I am falling' collapsed and before help could be given at the nearby hospital, breathed his last.

Despite his shortcomings, and there were quite a few, there was something brave and attractive about Captain James Kelly and I think it will be admitted readily that he *was* an outstanding character during the days in which he lived.

His name, as I think most will know, is perpetuated in the famous steps and street on Battery Point, as well as in two basins inside Tasmania's West Coast, the stormy coast he knew so well.

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BASSIANOBDELLA INGRAMI SP. NOV., FROM TASMANIA (Hirudinoidea: Richardsonianidae).[1]

Laurence R. Richardson[2]
(with 1 text figure)

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ABSTRACT

Differs from *B. victoriae* in having a wide marginal black band including the somital sense organs of the supramarginal and marginal lines, and continuous with the black venter.

Two specimens of an aquatic jawed sanguivorous leech from Tasmania, have a linear relationship of the organs on the anterior region of the male paired ducts, elongate cylindrical ejaculatory bulbs, a U-shape caecate vagina with subequal limbs, the procurrent limb terminating with a vaginal duct, and accordingly (Richardson, 1970) are members of the bassianobdellid group in the F. Richardsonianidae of the Australian Region. The vaginal duct is short, the common oviduct not intimately associated with it, both as in *B. victoriae*, but in the Tasmanian leech, the common oviduct is long, subequal in length to the procurrent limb of the vagina, differing from *victoriae* in which the common oviduct is shorter than this limb. A common oviduct of unusual length has been noted elsewhere (v. *Euranophila*, Richardson 1969a) and regarded as possibly generic in value. On the evidence here, it appears to be no more than specific. The short vaginal duct contrasting to the long and strongly muscularized duct in the Torresian species, continues to have value at the generic level.

The previously known bassianobdellids have a median black and three pair of dark longitudinal bands, the outermost bands extending along the line of the supramarginal sense organs, are defined medially by a pale stripe in the intermediate field and laterally by a pale marginal stripe which extends across the supramarginal and submarginal fields and includes the marginal sense organs. In the Torresian species, the pale marginal stripe is sharply separated in the ventral intermediate field from the dark venter. In *B. victoriae*, the pale marginal stripe is continuous with the pale venter. In the Tasmanian specimens, the margin is black, includes both the supramarginal and marginal sense organs, and is continuous with the black venter.

The Tasmanian specimens accordingly show dorsal dark bands only as the median, the inner and middle paired bands of the other known bassianobdellids, the outer paired bands of those leeches being included here in the marginal band which is topographically much wider in the Tasmanian leech.

Both specimens of the Tasmanian leech are closely similar morphologically, and in their morphological detail so closely resemble *B. victoriae* that at this time it would not be possible on morphological grounds to identify to species, specimens totally lacking colour and pattern. In the practice of R. Blanchard, this permits recognition of only one species.

Blanchard (1891, 1897, 1917, etc.) followed Moquin-Tandon (1846) in recognizing colour and pattern as highly variable within the species. Moquin-Tandon described 21 varieties of colour and pattern divided into 7 groups for *Hirudo medicinalis;* 11 varieties for *Haemopis sanguisuga* (the species which Blanchard (1891) made a synonym of *Limnatis nilotica).* Employing only simple diagnostic criteria, now proven neither specific nor generic in value, and completely disregarding the indications of colour and pattern, Blanchard (1897) reduced 15 species which had been described in the classical manner (colour, pattern, locality) to synonymy under *Sanguisuga granulosa* Savigny 1822, and provided a sub-genus *Poecilobdella* in the g.*Limnatis* to contain *granulosa* and *Hirudo javanica* Wahlberg 1855, retaining *javanica* as a species with 7 annuli between the genital pores, and so distinct from *granulosa* having 5 annuli between these pores. A brief examination of Blanchard's plate (1917: pl. vii) showing variation of pattern in '*Haemadipsa zeylanica*' shows the extravagant length to which he followed this principle.

Since 1891, the great majority of workers have been strongly influenced by Blanchard's practice. Johansson (1911) figures from Western Australian specimens and from accounts by various authors, 10 varieties of pattern in '*Limnobdella australis*', including patterns now recognizable as belonging to three distinct genera, one being the 7-banded pattern of *Bassianobdella.* In his study of the arhynchobdellids of India, Burma, and Ceylon, Moore (1927) made progress against the practice by separating *javanica* and *granulosa* at the sub-generic level on the basis of the distinctive nature of the median regions of the reproductive systems in each; described a new species; re-established *manillensis* Lesson 1842; but could go no further in the recognition of other of the early species. Moore later (1939) described species in the g. *Limnatis* which separate (Richardson, 1969a) into three distinct groups with morphological differences which elsewhere have had generic value. He identified leeches from four separate collections, all as *Limnatis nilotica,* noting variation in colour and pattern as described by Blanchard (1891). I find (Richardson, in press) that one of the collections studied by Moore contains leeches of a second distinct genus, separable by pattern. From his long experience, Moore (1958) concluded that in preserved material, the 'colour and pattern of leeches are as shifting sands for the purpose of taxonomic stability'.

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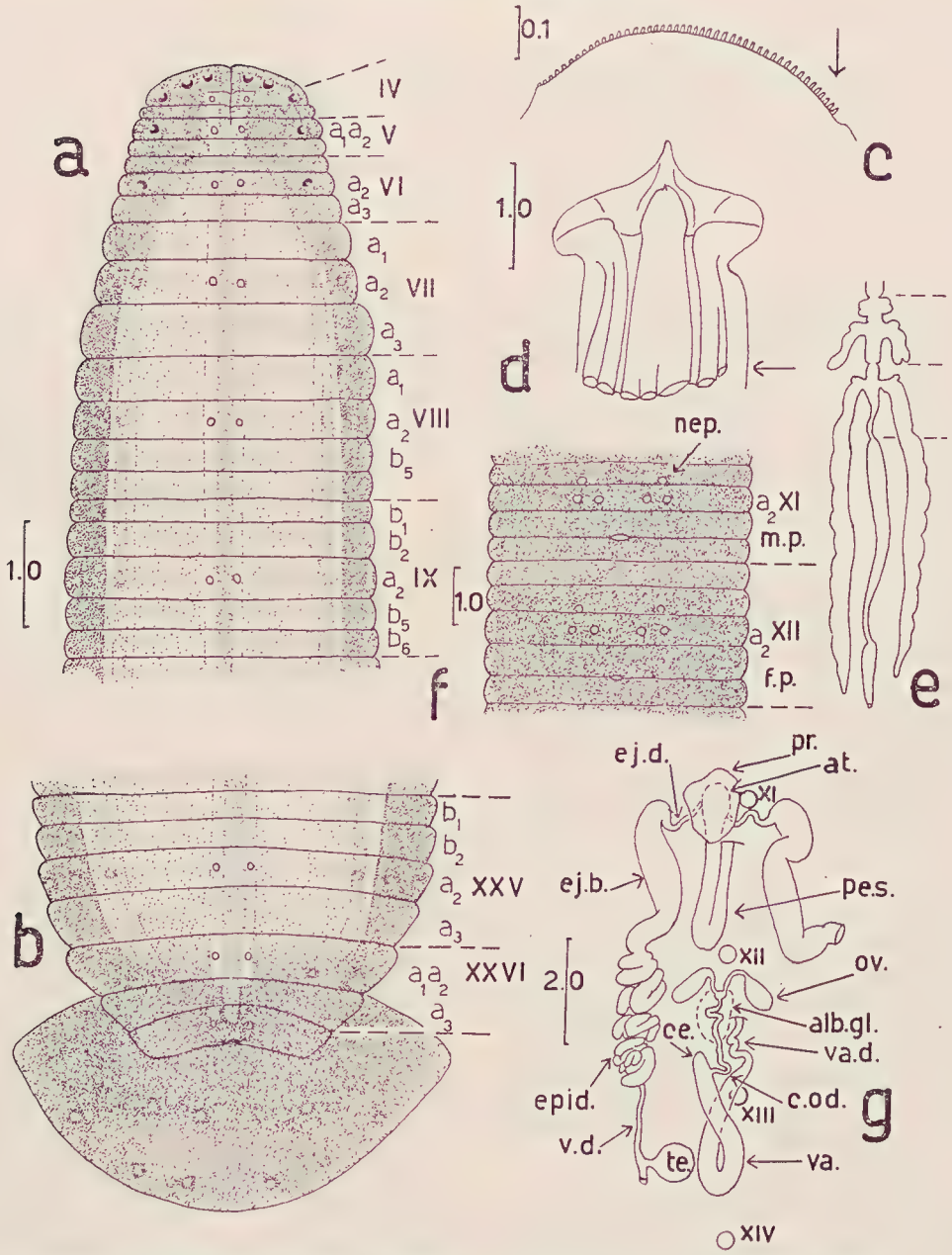

Fig. 1.—*Bassianobdella ingrami* sp. nov. a. Dorsal aspect somites i to ix, and b, somites xxv to xxvii and sucker, to show somital annulation and topography of pattern. c. Ventrolateral jaw of paratype, dental ridge (arrow indicates medial end) and dentition. d. Jaws, and pharynx opened along mid-ventral line to show internal muscular ridges (arrow indicates mid-point in length of pharynx). e. Crop, somites xviii and xix, caecation intestine and rectum. f. Ventral view of somites xi and xii, pattern and genital pores. g. Anterior region of male paired ducts (dorsal aspect lateral in figure), male median region, and female reproductive system.

Somites and somital ganglia indicated by Roman figures; annuli, 'a_2', etc. Abbreviations: alb.gl., albumin gland; at., atrium; c.od., common oviduct; ce., caecum; ej.b., ejaculatory bulb; ej.d., ejaculatory duct; epid., epididymis; f.p., female pore; m.p., male pore; nep., nephropore; ov., ovary; pe.s., penis sheath; pr., prostate; te., testis; v.d., vas deferens; va., vagina; va.d., vaginal duct.

All scales in mm. Drawings from the type, excepting c. from the paratype.

Above, briefly, is evidence of the inadequate systematization and confusion of species which led to persistence of the Moquin-Tandon/Blanchard tradition.

In my experience with the Australian arhynchobdellids, pattern is definable topographically and stable within the species. There has been no indication that longitudinal bands increase or decrease significantly in width in the individual leech held under a variety of conditions, nor in specimens from widely differing habitats. There is evidence that pattern develops rapidly in some species, later in others in which it passes progressively through juvenile and intermediate stages to the adult form, initially with wide dark bands, these divided later lengthwise by light stripes in terrestrial jawed sanguivores (Richardson, 1969b), and also in aquatics. In both, I have specimens showing the occasional survival of a juvenile pattern into the adult, even asymmetrically as an obvious anomaly with the pattern adult on one side, pre-adult on the other. Colour varies in intensity, primary colours ranging from light to full density; secondary colours (brown, orange, etc.) vary also in hue according to the relative representation of the basic primaries. Where the margin is pale, discontinuous with the venter, the venter may darken, as also the margin; but the two remain distinct and discontinuous. Although the Tasmanian leeches appear to exhibit a dark phase, the continuity of the margin and venter, and the topographic width of the margin on the dorsum, would remain in a light phase.

Accordingly, with the recognition of the Tasmanian leeches as a distinct species in the g.*Bassianobdella*, there is departure from the Moquin-Tandon/Blanchard tradition. Unfortunately, *B. victoriae* is known only in the preserved contracted condition, which does not permit reliable evaluation of some morphological differences known in the two leeches: the distinct longitudinal fissure median on the dorsum of i to iv, was not reliably indicated in *victoriae*; vii a_3 would seem longer than viii a_1 in both, not equal as I reported for *victoriae;* the position of the paramedians as central in the length of xxvi a_1 a_2 with the intermediates and supramarginals posterior, is very definite in the Tasmanian leech, and most unusual, yet these seemed all correctly posterior at the same level in *victoriae;* anterior secondary crop caeca were not evident in *victoriae;* the posterior level of fusion of the dorsal internal muscular ridges in the pharynx of the Tasmanian leech, contrasts to the fully anterior fusion close to the base of the jaw in *victoriae;* the long common oviduct contrasts to the short duct in *victoriae*. Differences of such nature may in time prove to be specific. Certainly, small differences in the size and number of the teeth earlier relied on for specific separation, have no such value within adequately defined genera.

The bassianobdellids as so far known to me, are leeches of moderate size, excepting a large and possibly new species from near Bathurst, N.S.W. Relaxed and preserved, this is 81.0 mm. long, generally dark greenish brown, the venter slightly paler; median band, black; paired bands, brownish black; intervening stripes, dark greenish brown; the margin, paler than and distinct from the venter. On the morphology of the reproductive systems, this leech belongs to the g.*Bassianobdella* and seems to be, at this time, a distinct species. This leech has: vii a_3 distinctly longer than viii a_1; in the mid-nephric series of somites, xv to xxi, the annuli are almost subequal, $b_1 = b_2$ slightly $< a_2 = b_5 = b_6$, and in the anterior and posterior series $a_2 = b_5 > b_6 > b_2 = b_1$; the somital sense organs, all central in xxvi a_1 a_2. Excepting the latter feature, there is conformity in *B. victoriae,* the Tasmanian leech, and the Bathurst leech, in vii a_3 being distinctly longer than viii a_1, in a_2 being the longest annulus and the 'b' category graded in complete 5-annulate somites. Both contrast to the Torresian species where vii a_3 is essentially equal in length to viii a_1, and the annuli in typical complete 5-annulate somites are equal in length, $b_1 = b_2 = a_2 = b_5 = b_6$.

The indications are that these differences in somital annulation will have systematic value. So far as I have seen, such differences have not yet been utilized in this way in the hirudiniform leeches.

The Tasmanian species is named after Miss D. Ingram in appreciation of her studies on Tasmanian leeches, the first attempt at a regional fauna, and a valuable contribution to the knowledge of the Australian leeches.

In that work, Miss Ingram (1957) had available only a single specimen of aquatic jawed sanguivore from Tasmania, 52.0 mm. long, fixed in Bouin's, and from this it was possible to do no more than briefly describe the externals, revise the somital annulation, and following Goddard, refer it to *Limnobdella australis* (Bosisto 1859), so providing the first record of such leeches in Tasmania.

Miss Ingram's specimen, from lagoons North of the Interview River/12 miles North of the Pieman River, had 16 complete 5-annulate somites; the dorsum brown, darker than the venter, and with only a dark median longitudinal 'streak', differing in this from the 5-banded pattern of leeches in the *'australis'* complex (Richardson 1970). For this reason, it seemed probable that it might be a member of the 7-banded bassianobdellid group, leeches which when preserved show only the median as a prominent band, the paired bands diminish in intensity to be detectable with some difficulty; but nothing further can be taken from Ingram's account.

With this second species, the g.*Bassianobdella* can now be more closely defined. I am still unable to reach a proper understanding of the nature of the vaginal duct. The present specimens confirm the difference in appearance and morphological relationships from the strongly muscularized duct known to me in other leeches (Richardson, 1969a).

g. *Bassianobdella* Richardson 1970.

Richardsonianidae; 16 complete 5-annulate somites; xxv, 4-annulate; teeth minute, about 45 to 50; no salivary gland papillae on jaws; pharynx terminating at viii/ix; primary caeca and postcaeca median on crop compartments; ejaculatory bulbs elongate, cylindroid, folding in contraction; median regions, bimyomeric mesomorphic, both formed on a primary loop, the caecate vagina extending along the recurrent and procurrent limbs of the loop to be elongate, U-shaped with subequal limbs, the procurrent limb tapering into a short moderately muscular vaginal duct distinctly shorter (¾ or less) than the recurrent limb of the vagina; common oviduct not intimately associated with the vaginal duct or the body of the vagina.

Size, medium. Pattern, continuous longitudinal dark bands, a median band and three paired bands of differing intensities.

Type species: *Bassianobdella victoriae* Richardson 1970. Bassian (Victoria).

Other species: *Bassianobdella ingrami* sp. nov. as below.

Bassianobdella ingrami sp. nov.

Fig. 1, a to g.

Type: Deposited, Tasmanian Museum and Art Gallery, Hobart. Coll. No. K 231. One specimen 51.0 mm. long; from a pond, ¼ mile from the beach, 6 miles East of the mouth of the Mersey River, Tasmania. Sept. 1969. Coll., P. Sabine. Dissected; left ventrolateral jaw removed, lost in preparation.

Paratype: Deposited, Australian Museum, Sydney. Coll. No. W 4268. One specimen, 46.0 mm. long; same location, date and collector as the type. Dissected; right ventrolateral jaw mounted separately.

The following description is taken from the type, excepting the jaw and dentition from the paratype.

General form.

In life: of medium size, capable of considerable extension. At rest, extended: elongate, moderately depressed, the obtusely rounded margins parallel along the greater length of the body, and the posterior sucker wider than the body when attached; moderately contracted: pregenital region, subconical, the body widening and low convex over the genital and testicular regions, the maximum width in the third quarter, the posterior sucker about ½ the maximum width; fully contracted: thickened, sub-elliptical in outline, dorsum moderately convex, margins obtuse, venter low convex, posterior sucker about ⅓ of maximum width. Swimming: extended, strongly depressed, margins widening slight along the pregenital region and then parallel, sharp but not strongly keeled excepting close to the sucker which is thin, of the width of the body and aligned with the body. An elegant but not rapid swimmer.

Relaxed, extended, preserved: elongate, low convex above and below, margins acute, sub-parallel along the nephric region, the width reducing in the post-nephric region to form the narrow base for the posterior sucker which is about equal to the maximum width.

In life: moderate contraction, 22.0 mm long; maximum extension, 52.0 mm long by 4.0 mm wide; extended at rest, 32.0 mm. Relaxed, extended preserved: total length, 51.0 mm; width at iv/v, 2.0 mm; at vii/viii, 2.3 mm and the depth 2.0 mm; at x/xi, 7.0 mm from the tip of the velum, width 3.0 and depth 2.2 mm; at the female genital pore, 14.0 mm from the tip of the velum, width 4.0 and depth 2.2 mm, and of these dimensions back to the end of the nephric region, narrowing in xxv on to form the base, 2.0 mm wide, for the posterior sucker which is 4.0 mm in diameter. Colour and pattern. Fig. 1, a, b, f.

In life: drab, blackish, a faint narrow longitudinal median black band, strongly black marginal bands, and brownish black between these bands; the marginal bands of the colour and continuous with the immaculate dull black venter; somital sense organs on both surfaces, enclosed in distinct and very obvious white circular patches, as also the nephropores and genital pores. Under the lens, the dorsum between the marginal and median bands, dull slate-grey suffused with reddish tonings which are lacking on the venter; the reddish tonings more dominant and almost coppery along the line of the paramedian sense organs as faint pale narrow stripes on either side of the median band; similar narrow stripes on either side of the intermediate lines of sense organs which then appear included in faintly indicated blackish narrow bands, much weaker than the median band; the paramedian field occupied by a faintly indicated wide dark reddish brown band excepting for the narrow pale stripe along the lateral margin of the field.

The pattern consists of: a narrow black band filling the median field from immediately behind the first pair of eyes to the posterior border of xxvi; an inner pair of very narrow light stripes along the paramedian lines including the sense organs between these limits; a middle pair of narrow light stripes along the lateral margin of the paramedian fields detectable between the middle of vii into xxvi; between the inner and middle paired stripes, a broad band completing the paramedian field from v/vi to xxvi a_1a_2/a_3 and increasing in width along the body as the body widens; a narrow outer pair of light stripes along the medial half of the intermediate fields detectable from in vii to xxvi a_1a_2; between the middle and outer paired narrow light stripes, a faint narrow dark paired band along each of the intermediate lines which include these sense organs; lateral to the outer paired light stripe, the marginal dark band completes the intermediate field, extends across the supramarginal and submarginal fields, is continuous with the venter, and includes the lines of supramarginal and marginal sense organs. The dorsum of the sucker is blackish grey, darker than the ventral face.

Preserved in formalin: the indications of the above pattern are slightly intensified but only the median and marginal bands are strongly defined; the paired narrow dark bands diminish to the same colour and intensity as the broad band of the paramedian fields; the narrow paired light stripes intensify and contrast more strongly with the general background colour than in life, the venter remains black.

Annulation. Fig. 1, a, b.

Very clearly defined in both the live and preserved leech; interannular and intersomital furrows, equivalent; somites not defined as such, but recognizable by the transverse rows of white patches enclosing all somital sense organs on both dorsal and ventral aspects and plainly identifying the neuromeric annuli; in extension, annuli such as vii a_3, viii a_1, $a_2 = b_5$ along the nephric region, are all distinctly elongate and the latter show as couplets separated by triplets of shorter annuli; sensillae, not detectable; nephropores, small, distinct, each in a white patch posterior on a_1 and b_2 just median to the line of ventral intermediate sense organs; genital pores, obvious in white patches. Relaxed, extended, preserved: as in life, but the somital sense organs contracted somewhat and relatively smaller; no sensillae detectable.

The rounded margin of the velum proper of the anterior sucker continuous with the dorsolateral, lateral and ventral regions of the margin of the sucker. In the preserved specimen, as also in life, a distinct furrow median on the dorsum of the velum extends from the

margin to iv/v. The first transverse furrow, iii/iv, extending across the median field, does not reach the margin and incompletely divides the velum into an anterior portion, i to iii carrying the 1st and 2nd pairs of eyes, and iv, 2-annulate with the 3rd pair of eyes and 1st obvious paramedians in $a_1a_2 > a_3$; iv/v, a distinct furrow across the dorsum, weakening laterally and not sharply defining the posterior margin of the dorsolateral lobe; v, 2-annulate above, the 4th pair of eyes and 1st obvious supramarginal sense organs in $a_1a_2 > a_3$, the furrow a_1a_2/a_3 ending in the submarginal field, and uniannulate v forming the lateral and ventral margin of the sucker; vi, 3-annulate above, $a_1 < a_2 > a_3$, the 5th pair of eyes in a_2, and 2-annulate below, $a_1a_2 > a_3$, vii, complete 3-annulate, $a_1 < a_2 < a_3$; $viia_3$ distinctly longer than viii a_1 in the live leech and in the preserved specimen; viii, 4-annulate, $a_1 > a_2 > b_5 > b_6$, the 1st nephropores on a_1; ix to xxiv, complete 5-annulate, nephropores on b_2 (total 16); ix, $b_1 < b_2 < a_2 > b_5 > b_6$; x to xviii, $b_1 < b_2 < a_2 = b_5 > b_6$ (i.e. $a_2 = b_5 > b_6 > b_2 > b_1$); xix to xxiii, $b_1 = b_2 < a_2 = b_5 > b_6$; xxiv, $b_1 = b_2 = a_2 > b_5 > b_6$, the last nephropores on b_2; xxv, incomplete 4-annulate, $b_1 = b_2 < a_2 < a_3$ above, with the somital sense organs central in the length of a_2, and a_2 the last annulus across the venter; xxvi, 2-annulate above, $a_1a_2 > a_3$, the paramedian sense organs central in the length of a_1a_2, but the intermediates and supramarginals posterior in the annulus in the usual position—the positions are the same in the live and the preserved leech; xxvii, uniannulate; anus at the posterior border of xxvii.

Dorsum of the posterior sucker with 5 concentric furrows and rows of paramedian, intermediate and supramarginal sense organs, each in a white patch.

There are some abnormal furrows: ix b_5, subdivided on the left; x a_2, on the right, as also xii a_2 and xiii b_6; but these are erratic and unrelated to the typical somital annulation.

Alimentary tract. Fig. 1, c, d, e.

Jaws, of moderate size, compressed; the dorsomedian jaw in profile at the medial end, about as tall, 0.5 mm, as wide at the base, housed in a broadly open groove, the ventrolaterals in shallow pits, all with such poorly defined margins as to be nonmorphological; (paratype: the dental margin of the ventrolateral jaw, low convex and appearing nearly straight along most of the length, and about 0.6 mm long; the teeth, about 45, spaced, minute, the teeth at the median end about 0.02 mm high, the row diminishing very gradually in height so that those in the middle of the row are still 0.018 mm; no salivary gland papillae on the jaws).

The entrance to the pharynx at vii/viii, narrow, barely wider than the base of the dorsomedian jaw; the lumen, narrow, tapering; internal muscular ridges arranged as a dorsomedian and ventrolateral pairs, each pair joining to enter the base of the appropriate jaw; none ending independently on the entrance to the pharynx between the bases of the jaws; extrinsic radial musculature, sparse; dorsal salivary glands, compact right and left masses, each mass with a large column of aggregated ducts.

Pharynx terminates at viii/ix, followed by a simple compartment in ix; x and xi with subequal small anterior and median pairs of simple caeca within the median chamber; xii, posteriorly, the anterior pair remaining relatively small and retained in the median chamber, the median pair, increasingly tubular, extending into and reflected posteriorly in the paramedian chamber so that from xv to xviii the ends lie lateral to the anterior caeca of the following somite; in xix, there are no anterior caeca, the postcaeca originate in the anterior quarter of the compartment, which behind this is narrowly tubular, ending at xix/xx connecting terminally to the wider tubular intestine which tapers to connect terminally at xxiv/xxv to the rectum. The postcaeca extend into xxvi.

Reproductive system. Fig. 1, f, g.

The specimen is gravid male.

The genital pores at xi b_5/b_6 and xii b_5/b_6; the median regions, bimyomeric, mesomorphic.

The testes, simple saccular, the 1st pair at xiii/xiv, last pair at xxii/xxiii, total of 10 pairs located in the median chamber, connecting laterally each by a short vas efferens to the vas deferens in the paramedian chamber extending anteriorly to the mid-level in xiii where it enlarges into the tubular, tortuous epididymis much folded on itself and ending at the mid-level in xii, connecting to the dorsal end of a short vertical limb of the elongate cylindrical muscular ejaculatory bulb which at the level of ganglion xi reduces to a delicate ejaculatory duct, passing through the paramedian palisade to connect to the anteroventral aspect of the atrium in the median chamber; the atrium continuous with the recurrent limb of the folded muscular penis sheath, reflecting at ganglion xii and continued as the procurrent limb ending at the male pore.

The ovaries somewhat elongate subovoid in the posterior half of xii, joining by short oviducts to the distinct small atrium; the common oviduct, elongate, relatively long, much folded on itself initially, then less so and extending posteriorly to connect subterminally to the elongate cylindrical caecate vagina; the vagina formed on the posterior portion of the primary loop, extends into the anterior annuli of xiv, consisting of subequal recurrent and procurrent limbs; the procurrent limb, reducing in diameter to continue as the short slightly tortuous vaginal duct, much shorter than and only about ½ the length of the procurrent limb of the vagina; wall of the vaginal duct somewhat translucent, not obviously opalescent or strongly muscular, appearing to have a relatively large lumen.

The common oviduct, enclosed on all sides by the albumin gland, is not intimately associated with the vaginal duct, and can be lifted freely away from it without dissection. The common oviduct is distinctly longer than the vaginal duct.

Prostate glands, a thick investment covering the atrium and extending briefly along the penis sheath. The albumin glands a heavy investment of the anterior half of the common oviduct, extending partly onto the atrium.

Paratype.

General form and colour, as the type, excepting after preservation the marginal band on the dorsum is divided into a slightly paler median portion in the lateral half of the intermediate field and the medial half of the supramarginal field, and including the line of the supra-

marginal sense organs, but this band is nowhere defined laterally by a distinct stripe in the supramarginal field, and is definitely paler than the venter.

Annulation, essentially as in the type, excepting xxvi/xxvii is only weakly defined in the median field. Alimentary canal, as in the type, with the anterior secondary caeca not as clearly defined. Reproductive system, as in the type.

The vaginal duct cut across showed a well developed circular layer with what appears to be a longitudinally rugose lining epithelium.

General notes.

Mr P. Sabine describes the pond as about 20 feet in diameter, down to 3 feet deep; the bottom, sandy with some mud and rotting vegetation; swampy margins continuing back into ti-tree excepting on the south side; part of a coastal swamp complex defined by sand dunes on the seaward side.

Taken in September, both or one or the other would be seen moving in the jar, or concealed for a period of a week or more, through to January. From February to early August, both were commonly concealed for periods of several weeks, with one occasionally and rarely seen at a time. In early August, both became fully active at the one time.

A blood meal was taken from a tadpole.

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REFERENCES

BLANCHARD, R., 1891: Courtes notices sur les Hirudinées. 1. Sur la sangsue de cheval du nord de l'Afrique (*Limnatis nilotica* Savigny 1820). *Bull. Soc. Zool.* France. **16,** 218-21.

————, 1897: Hirudinées des Indes Néerlandaises. In: Weber. M. Zool. Ergebn. in Niederl. Ostindien. **4,** 332-56.

————, 1917: Monographie des Haemadipsines (Sangsues terrestres). *Bull. Soc. Path. Exot.* x (7), 640-75.

INGRAM, D., 1957: Some Tasmanian Hirudinea. *Pap. Proc. Roy. Soc. Tasmania.* **91,** 191-232.

JOHANSSON, L., 1911: Hirudinea. In: Die Fauna Südwest-Australiens. **3**(12), 407-31.

MOORE, J. PERCY, 1927: Arhynchobdellae. In: Hirudinea. Fauna of British India. London : 96-302.

————, 1939. Additions to our knowledge of African leeches (Hirudinea). Proc. Acad. Nat. Sci. Philadelphia. 90:297-360.

————, 1958: Leeches (Hirudinea) in the collection of the Natal Museum. *Ann. Natal Mus.* xiv(2), 303-40.

MOQUIN-TANDON, A., 1846: Monographie de la familee des Hirudinées. 2nd Edn., 1-448+ Atlas.

RICHARDSON, LAURENCE, R., 1969a: A contribution to the systematics of the hirudinid leeches, with description of new families, genera, and species. Acta Zool. Hung. xv (1-2): 97-149.

————, 1969b: On a distinctive new subequatorial Australian quadrannulate land-leech, and related matters. Aust. Zool. **15**(2), 201-13.

————, 1970: *Bassianobdella victoriae* gen et sp. nov. (Hirudinoidea: Richardsonianidae). Mem. Nat. Mus. Vic. **31,** 41-50.

————, (in press): A new genus and species of Sudan leech formerly confused with *Limnatis nilotica* (Hirudinidae s.l.:Hirudinea). Bull. Brit. Mus.. (Nat. Hist.).

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OBSERVATIONS ON SOME TASMANIAN FISHES—Part XVIII

By

E. O. G. Scott

(one text figure)

ABSTRACT

Two new forms are described: *Nannoperca australis flindersi subsp. nov.* (Nannopercidae), from Flinders Island; *Kyphosus diemenensis sp. nov.* (Kyphosidae), from the north coast of Tasmania (figured).

One species is added to the local list: *Crapatalus arenarius* McCulloch, 1915 (Leptoscopidae).

Some miscellaneous observations are made as follows. Haplochitonidae: *Lovettia sealii* (Johnston), 1883, specification of a sample, general remarks on whitebait. Syngnathidae: *Urocampus carinirostris* Castelnau, 1872, supernumerary opercular ridges, records of pipefish breeding seasons; *Leptoichthys fistularius* Kaup, 1853, regeneration of caudal extremity, scute development; *Lissocampus caudalis* Waite & Hale, 1921, disposition of ova in marsupium. Nannopercidae: general remarks on family, descriptions of small samples of *Nannoperca australis australis* Günther, 1861 and *N.a. tasmaniae* (Johnston), 1883, with some results at variance with published specifications, data on 2 undetermined specimens from King Island, new subspecies as above. Kyphosidae: key to Australian members of family, new species as above (first Tasmanian kyphosid). Xiphiidae: *Xiphias gladius* Linné, 1758, dimensions of an East Coast example, taxonomic status of the Australian broadbill swordfish. Ophidiidae: *Genypterus microstomus* Regan, 1903, large examples, key to Tasmanian members of family. Tetraodontidae: *Tetraodon armilla* McCulloch & Waite, 1915, notes on a specimen, remarks on the family.

INTRODUCTION

This paper follows the general plan of others in the series. Attention may be drawn to, in particular, the following conventions. Linear measurements are given, unless otherwise stated, in millimetres, the name of the unit commonly being omitted. The abbreviations *Ls, Lt, TLs, TLt* denote standard length, total length, thousandths of standard length, thousandths of total length, respectively. Standard derivations are calculated with *n* degrees of freedom, and coefficients of variations are computed from values thus obtained. Certain other conventions are noted in earlier contributions.

Family HAPLOCHITONIDAE

The spelling Aplochitonidae is favoured by most Australian authors—*e.g.* McCulloch (1915, 1929), Blackburn (1950), Munro (1957), Whitley (1968): however, the family name is rendered as Haplochitonidae by Günther (1880), Berg (1940), Greenwood, Rosen, Weitzman & Myers (1966), and others.

Two Australian species: *(a) Prototroctes* Günther, 1864, (1) *P. maraena* Günther, 1864; *(b) Lovettia* McCulloch, 1915 (2), *L. sealii* (Johnston) 1883. The former has been recorded from New South Wales, Victoria, Tasmania, the latter is endemic to Tasmania. [The 'N and E. Tas.' of Munro (1957:30) is to be interpreted as including such rivers as the Esperance (county Kent) and Huon (Kent/Buckingham), which, though, strictly speaking, on the east coast of the Island, are generally spoken of as southern rivers (and are so treated in Blackburn's definitive paper (1950) on *Lovettia sealii*)]. In that paper the specific trivial name is rendered *seali*, a proceeding not in accordance with Opinions of the International Commission on Zoölogical Nomenclature. The genus *Lovettia* is represented only by the Tasmanian fish: however, *Haplochiton* [*Aplochiton*] Jenyns, 1842, in which it was originally placed by Johnston, includes 2 species from South America and nearby islands. A distinction between *Lovettia* and *Haplochiton* unknown to McCulloch when he established his genus has been noted by Blackburn; the genital opening and the anus being quite differently located in males and females of the former, but not in those of the latter, genus. *Prototroctes* is represented in New Zealand by *P. oxyrhynchus* Günther, 1870.

Key to TASMANIAN HAPLOCHITONIDAE

Body with scales. Lateral line on scales in hinder part of body only. Ventral orginating in advance of middle of standard length. No anal papilla. Depth < 6 (about 4-4.5) in standard length; which is $>$ 100 mm (reaching about 250) - *Prototroctes maraena*

Body naked. Lateral line a series of pores in a linear depression, extending along most of body. Ventral originating at, or behind, middle of standard length. Anal papilla present; near origin of anal fin in female, in advance of ventral fin (commonly near pectoral fin) in male. Depth > 6 (about 8-10) in standard length; which is <100 mm (seldom, if ever, exceeding 75) - - - - - - - - - - - - - *Lovettia sealii*

Genus LOVETTIA McCulloch, 1915

Lovettia sealii (Johnston), 1883

Haplochiton sealii Johnston, 1883, *Pap. Proc. Roy. Soc. Tasm.* (1882): 128. Type locality, Derwent R., Tasmania.

Lovettia sealii McCulloch, 1915, *Proc. Linn. Soc. N.S.W.*, XL, 2: 259, pl. xxxv, fig. 2.

Whitebait. The term whitebait is used differently in different countries, designating a variety of small fishes, usually from salt or brackish waters. McDowall (1964) quotes Graham (1956) as stating that in England the name is applied broadly to a mixed catch, made up mostly of young sprats, together with the young of shad, herrings, sticklebacks, and including even shrimps; in Japan to the young of the sea perch; in Germany and Italy to the young of various sea fishes: an editorial note in *Australian Fisheries Newsletter* of April, 1965 observes 'In U.S.A. it is used to describe *Meridia beryllina* in Atlantic coast States.' In New Zealand, while a number of conflicting opinions as to the nature of the

local whitebait have been advanced from the time of Powell (1869) onwards, 'there has long been general agreement among ichthyologists that whitebait are simply the juveniles of *Galaxias attenuatus*' (McDowall, 1964). He notes, however, 'in some parts of the country and at different times of the year, usually towards the close of the whitebait season, the whitebait run includes the young and adults of *Retropinna, Gobiomorphus,* and, during the last century, reputed *Prototroctes*. A second-class whitebait is sold on the Auckland fish market, and this is obtained from the sea. It includes the young of pilchards and other marine fishes and also juvenile *Retropinna*.' Recent investigations have shown species of *Galaxias* other than *G. attenuatus* are often represented in significant numbers, Woods (1963:29) defining whitebait as 'the transparent free-swimming and shoaling juveniles of at least five species of galaxias'; while, in the paper just cited, McDowall observes (p. 145). 'The "whitebait" of fishermen is thus primarily *G. attenuatus,* with *G. fasciatus, G. postvectis, G. brevipinnis* and probably *G. argenteus* making up a small proportion of the catch.' Earlier, Woods (1963:29) had included *G. campbelli* in the list, and McDowall (1966) confirmed his earlier (1964) conclusion that *G. argenteus* also has a marine whitebait stage in its life history. An account of the New Zealand whitebait fishery has been given by McDowall (1968). See also important papers by McDowall (1965) on the composition of the New Zealand whitebait catch of 1964, and by Woods (1968) on growth characteristics, pigmentation, and the identification of whitebait—on identification see further Scott (1968:5). For a general treatment see Whitley (1935).

Tasmanian whitebait in 1934. In Tasmania 'whitebait' is characteristically and traditionally applied to the haplochitonid *Lovettia sealii* (Johnston), 1883; though Johnston himself (1883:62) stated (apparently mistakenly; perhaps having in mind another run) the local whitebait consists essentially of the fish now known as *Retropinna tasmanica* McCulloch, 1920, accompanied in varying numbers by *G. attenuatus* (Jenyns), 1842 and *Atherina* spp. The composition of a sample of 200 individuals, caught in the Tamar River, Devon/Dorset, in September 1934, was noted in Part III (1936:113) as being 192 *Lovettia sealii* (*Lt* 41.5-56.4), 7 *Galaxias attenuatus,* 1 *Galaxias* sp., probably *G. truttaceus* (58); while that of a second sample of the same size, taken in the Mersey River, near Latrobe, Devon, in the same month was 172 *L. sealii* (55-65), 23 *G. attenuatus* (38.5-52), 2 *G. sp.,* probably *G. truttaceus* (49-65). This apparently represents the first recognition of *G. truttaceus* in our whitebait.

Tasmanian whitebait, 1941-46. The effective fishery dates from 1941, procurement earlier usually being occasional and relatively small. In response to requests from a canning firm and from a Tasmanian organisation of professional fishermen, a comprehensive study was initiated by the C.S.I.R.O. (now C.S.R.O.); leading to the publication of the admirable paper of Blackburn (1950). Blackburn recorded that in 95 samples of whitebait totalling 79,958 specimens, taken from 14 rivers during 1942-46, the numbers of *G. truttaceus* (Cuvier), 1816, *G. attenuatus* (Jenyns), 1842, *Retropinna tasmanica* McCulloch, 1920, *Tasmanogobius lordi* Scott, 1935, *Ctenogobius tamarensis* (Johnston), 1883, *Atherinosoma tamarensis* (Johnston), 1883 were 1311, 204, 25, 30, 4, 1, or in all 1575 variants (2%); the variants predominating over *Lovettia* in only 2 of the samples, and being altogether absent in 57 samples. Of the 2 galaxiids, *G. truttaceus* was relatively more numerous in northern samples, at 20.25 per thousand as against 11.5; while *G. attenuatus* was relatively more abundant in southern samples, at 49.8, *cf.* 1.10. The scarce retropinnid stood at 0.60, 0.15 per thousand in southern, northern samples, respectively. The 3 other species, clearly adventitious, were met with only in northern material, *Tasmanogobius* occurring in 2 samples only. Blackburn noted 'statements by north coast buyers indicate that *Galaxias truttaceus,* the principal variant, does not run until late in the whitebait season'; and concluded 'it can safely be said that over 95 per cent. of the Tasmanian fish marketed as whitebait are *Lovettia*.'

Tasmanian whitebait, 1964. In 1964 the writer determined for the Inland Fisheries Commission upwards of 9000 fish in a number of samples from rivers in north-western Tasmania. Lynch (1966) has discussed changes in the species composition indicated by some of those data. His tabulation of 9 samples, 1 each from the Duck, Emu, Inglis, Rubicon, Leven, 2 each from the Forth, Mersey rivers, taken between August and November 1964, works out, by species, as follows: *Lovettia sealii* represented in 3 samples, 559 individuals (540 in one sample), 24.7% of total; *Galaxias attenuatus* 5, 1002, 44.3%; *G. truttaceus* 9, 358, 15.8%, *G. weedoni* 3, 340, 15.0%; *Retropinna tasmanica* 1, 5, 0.2%. Lynch records (p. 15) 'In the 1964 fishing season in the Forth River no whitebait *(Lovettia seali)* was taken in the catch up to the end of October. More than 90 per cent. of the catch by numbers was the fry of mountain trout (*Galaxias weedoni* Johnstone)'. [The proposal here advanced, to remove from the widely distributed *Galaxias truttaceus*—one of the two Tasmanian galaxiids commonly recognized by name by non-specialists—its genuinely vernacular and almost universally used title of mountain trout, and transfer this to the relatively unknown (and apparently rather local) *G. weedoni* would seem to invite confusion, and to have little likelihood of general acceptance.]. The emergence in the catch in significant numbers of *G. weedoni* Johnston, 1883 (a species inadequately collected and recognized since Regan's (1906) revision of the family; and, at the present time, better known in the juvenile than in the adult stage), not represented in the extensive 1942-1946 material of Blackburn, is a circumstance of much interest. McCulloch's species *Retropinna tasmanica* is inadvertently attributed in the paper cited to Johnston [who (1891) listed our smelt as *R. richardsoni* Gill—a synonym not noted in the Check-List (McCulloch, 1929:46).].

The rise in the commercial catch of Tasmanian whitebait from 1941 (in northern rivers, 1943) when the fishery was effectively initiated, to a peak in 1947 probably largely reflected increased interest in, and efficiency of, the industry. Total annual catches for these 7 years were (in thousand lb) 53, 46, 206, 206, 357, 774, 1,065. Then 1948, with a drop to 348, saw the beginning of a decline, probably largely attributable to overfishing, that continued till in 1956 the catch stood at 4 (increasing in 1963 to 12). The observations noted above would seem clearly to indicate that the period of decline was one, not only of absolute, but also of relative decrease in the abundance of *Lovettia.*

Tasmanian whitebait, 1964-1969. Since 1963 the industry has experienced a notable revival, the yearly catches from 1964-5 to 1968-9, as recorded in the March issue of *Australian Fisheries* for the years 1966-1970 [in 1966, title *Australian Fisheries Newsletter*] being (here given to nearest thousand lb) 41, 71, 95, 55, 82, respectively. It seems probable the increase is due, at any rate in part, to a significant regeneration in the *Lovettia* stock.

Tasmanian whitebait sample, 1970. No detailed investigation of the 1970 run has been undertaken: however, the presence in the market, at any rate upon occasion, of a pure or virtually pure supply of *Lovettia* may profitably be recorded—all fish in a (5-cent) sample of 128 individuals purchased in a greengrocery store in Devonport, Devon on 9 August 1970 proving to be the haplochitonid.

Despite its small size (largest reported individual a female of *Ls* 70) Lovettia is readily sexed, exhibiting marked sexual dimorphism in *(i)* the anatomy of the alimentary and urinogenital systems, observable externally [first recognized independently, by Professor V. V. Hickman and Mr A. V. G. Paddon; further investigated and figured by Blackburn (1950: 157, fig. 1)]; *(ii)* size of pectoral fin [Blackburn (p. 159)]; *(iii)* size of ventral fin [here reported from our material]. Sexual dimorphism in vertebra number was noted by Blackburn; he drew attention to reports by other workers of the existence of this very unusual condition in three osmerids; several of which exhibit also sex differences also in the size of some fins.

(i) In the female the urogenital papilla is median, and is located well back, in the customary position, either being partly embraced by the tips of the adpressed ventrals, or lying immediately behind in the short interval between them and the origin of the anal fin; the most conspicuous element is a tongue-like process, rather, or decidedly, longer than wide (clearly seen in Blackburn's photographs, pl. 1, figs 1, 2); this process is more or less tumid basally behind, the free portion being received, when laid back, in a subtriangular pit, bordered, in some individuals, with low ridges traceable back nearly to, to, or occasionally slightly past the anal origin; immediately in advance of the process is an elevated region that may perhaps be regarded as constituting the papilla proper, varying in form and development in our material (probably enlarging as oviposition approaches) from a compact mamilliform mass to an elongated ovoid mass or inflated ridge, and ranging in longitudinal extent from less than one-third to more than one eye-diameter: the minute urinary pore is located on the large process very close to its base, the larger genital opening lies against a median concavity in the outline of the base of the process, while the anus is just anterior to the rounded papilla or set on the forward elevated continuation of it: in our specimens the whole structure ranges from slightly less than one to more than two eye-diameters. In the male the urogenital papilla is median, and is placed well forward, characteristically between, or partly behind, the pectoral bases (Blackburn notes that it may occasionally occur further back, at various positions up to the pelvic girdle); it usually presents itself as a subtriangular process, often ending in two points; it in fact consists of two subtriangular lobes, commonly closely apposed (in the preserved material); a narrow groove wholly or partly separates their bases: the urinary opening lies at the base of the hinder flap, the genital opening in the groove, the vent in the anterior half of the front flap—there has thus come about the curious arrangement in which the intestine, after a short backward course, curves forward, to open beneath the stomach at a point anterior to its own beginning.

(ii) Blackburn describes the length of the pectoral fin in males as equal to the distance from snout tip to posterior margin of operculum; in females as equal to distance from snout tip to posterior margin of eye. In some of our males length of pectoral slightly exceeds length of head.

(iii) A third point of external difference between the sexes, not hitherto reported, but found in our material, is afforded by the greater size of the ventral fin in the male. Typically, in these specimens, length of ventral in females is equal to interval from opercular border about to, or a little beyond, middle of eye; in males from the same origin to about midway between eye and snout tip, at times almost reaching the latter. It is not possible to make a satisfactory comparison between the sizes of pectoral fins in Blackburn's photographs of 3 females (pl. 1) and 3 males (pl. 2); though the latter are perhaps a little longer. The standard figure of the species, that provided by McCulloch (pl. xxxv, fig. 2) in the paper in which he established the genus *Lovettia,* is of a female, the external genitalia being clearly depicted. It shows length of pectoral as exceeding distance from snout tip to end of eye, but shorter than distance from snout tip to margin of preoperculum: the length of the ventral as depicted is equal to distance from opercular border to a point below eye.

Of our 128 fish, 19 (14.9%) are females—*cf.* 30.99, 30.34 for Blackburn's 48090 northern, 30293 southern, examples.

Most of our females are in the first of the 4 stages of gonad development recognized by Blackburn in the classification of his material — the filling stage, with ovaries extending forward to region of stomach, but occupying only about two-thirds of body cavity; the eggs, as preserved, white, opaque, ranging in diameter from about 0.5 to about 1.0 mm. A positive correlation between number of large eggs (about 100-200) and size of fish was reported by Blackburn (table 5). In the present sample 3 females of Ls 47.9, 50.0, 52.0 bore 129,138,138 ova, respectively.

Of the females of the present sample, 4 are in the first of the 5 stages of pigmentation recognized by Blackburn ('no spots on the body, or less than 10 on the posterior part of the back'), 15 in the second stage ('spots numerous on the back, but not extending right to the head'): of the males, 1 is in the first stage, 39 in the second, 69 in the third ('spots on the back extending to the head, but less than 5 on the posterior end of each lateral line'). Within these broad classes there occurs of course considerable variation; thus, in the second stage the spots may be confined to the caudal peduncle, or may extend quite close to the head, and in the third stage there exist considerable differences in number, size, and intensity of the chromatophores. It should be observed that in both the first and second stages, with chromatophores on the back of the body absent or not

extending forward to head, the head itself is constantly spotted, often quite strongly, thus representing a separate site of pigmentation. Being concerned only with broad classes for the ready recognition and specification of degree of pigmentation, Blackburn devoted no attention to separate markings. One very conspicuous pigmentation pattern, well developed in all our females, has the form of two linear series of dark markings, each consisting of a number, modally about a score, of short black dashes (or dashes in association, usually anteriorly, with dots) that begin from, or near, a common point, about at level of opercular border, rapidly diverge, and run back, more or less parallel, but often with some approximation posteriorly, to about level of ventrals: anterior to its initial point of divergence, the marking may continue forward, as a median line of several segments or dots, on to the under surface of the head, between the branchiostegal membranes, reaching, as a maximum extension, to the point at which the membranes become contiguous, below the eye. In males this marking may be similar, but it is often less clearly developed, and not infrequently obsolescent or obsolete. No pigmentation on the lateral line is found in our material. On the head pigmentation varies considerably in disposition and amount: there are indications that pigmentation on the occiput may precede pigmentation elsewhere on the dorsum of the head. Lips experience pigmentation early, and there is commonly a cluster of chromatophores on the chin. Most individuals exhibit a regular line of 10-15 dots flanking the anal base on either side, the pigmentation often continuing caudad as two lines, a single line, or irregularly. Discrete internal pigmentation, clearly apparent through the body wall, is a noticeable feature of most females, the usual pattern being that of two longitudinal lines of melanophores, one on the lower part of each flank, modally beginning a head-length, or more, behind the operculum, and extending, with little or no interruption, to vent; each line is usually uniserial, but either or both may be biserial or, at least in part, triserial. Dissection shows these melanophores are located in the peritoneum. Internal melanophores can be detected in our males only by careful searching, in contrast to their conspicuous character in females: moreover, they originate at about level of pectorals, and usually extend back for a distance less than the distance of their origin from snout tip, *i.e.*, they are confined to the anterior half, or so, of the coelom occupied by the alimentary canal. However, in spite of an externally less obvious deposition of discrete pigmentation in males in the region traversed by the alimentary canal, the peritoneum in males tends, as noted by Blackburn, to be on the whole darker than in females; males in the present sample often having this whole region dark bluish. A dusky bar at caudal base is found in some individuals of both sexes. Of several minor instances of pigmentation found in some individuals the most constant is an arc of several melanophores outling part of the border of the operculum.

As preserved in alcohol, our specimens are largely dead white, touched here and there with yellow (exceptionally with yellow and some orange). The yellow occurs most commonly along the lateral line (either throughout its entire length or confined to its posterior part; the line of colour usually being in the former case more intense, and somewhat wider, posteriorly); on the occiput, and on other parts of the head, particularly the opercle, on base of caudal.

In Blackburn's material for which mean standard length by sexes is recorded the female value exceeds the male in all 44 northern samples (by 0.83 - 5.03 mm: mean (unweighted) 3.25), while in the southern material the female value is less than the male in 2 samples (by 1.04, 0.28), exceeding it in the remaining 22 samples (by 0.12 - 2.49; mean (unweighted) 1.17). In our sample female *Ls* exceeds male by 2.69, or by 5.7% of latter; $t = 2.10^*$. An interesting indication of the greater length of the female is afforded by the fact that of the 28 individuals in our sample of *Ls* $\geq$ 50, no fewer than 12 are female: however, the largest male, *Ls* 56.8, is longer than the largest female, 54.0.

Frequency distribution in 15 1-mm classes (42.0-42.9 . . 56.0-56.9): males 2, 6, 7, 19, 11, 25, 12, 11, 6, 7, 1; 0, 1, 0, 1; females 0, 0, 0, 1, 2, 1, 2, 1, 7, 2, 2, 0, 1, 0, 0.

Specification of standard length: 109 males, 42.2-56.8, $\bar{x}$ 47.28 $\pm$ 0.44, σ 4.57 $\pm$ 0.31 *V.* 9.7 $\pm$ 0.7; 19 females, 45.0 - 54.0 $\bar{x}$ 49.97 $\pm$ 1.74 σ 7.55 $\pm$ 1.23 V 15.1 $\pm$ 2.5. The male median is 47.1, the female 50.1.

Family SYNGNATHIDAE

Genus **UROCAMPUS** Günther, 1860

Urocampus carinirostris Castelnau, 1872

Urocampus carinirostris Castelnau, 1872, *Proc. Zool. Acclim. Soc. Vict.*, 1:200. Type locality, Melbourne Markets.

Urocampus coelorhynchus Günther, 1873, *J. Mus. Godef.*, 1, 2:103. Type locality, Sydney.

Series data. As remarked earlier in these studies, treatment in the literature of Australian syngnathids is in general confined to description of one or a few individuals, data based on a series of specimens rarely being available. Some first steps to fill the lack, based on samples ranging from small to moderate, have been taken in these observations—*e.g.*, *Mitotichthys tuckeri* (Scott), 1942, (1960: 87; 1964: 93), *Stigmatopora argus* (Richardson), 1840 (1963: 19), *Urocampus carinirostris* Castelnau, 1872 (1965: 58), *Syngnathus curtirostris* Castelnau, 1872 (1964: 85; 1966: 93). Some specifications are here given of a sample of 15 specimens of *Urocampus carinirostris* netted by Mr C. H. Rittmann in April 1970 at Hillwood, Tamar River, Dorset.

Standard length. The *Ls* range is 38.3-93.5, mean 68.89 $\pm$ 3.66, standard deviation 14.2 $\pm$ 2.6, coefficient of variation 20.6 $\pm$ 3.9; within $\bar{x} \pm \sigma$ there occur 11 entries (expected in normal distribution, 10).

Head, trunk tail as TLs. For head we find $\bar{x}$ 8.2 $\pm$ 1.4, σ 5.6 $\pm$ 1.0, *V.* 6.9 $\pm$ 1.3; for trunk, $\bar{x}$ 185.6 $\pm$ 17.8, σ 17.8 $\pm$ 3.2 *V.* 9.6 $\pm$ 1.8; for tail $\bar{x}$ 733.7 $\pm$ 4.9, σ 19.1 $\pm$ 3.5, *V.* 2.6 $\pm$ 0.5. For these dimensions the numbers of entries lying within the range $\bar{x} \pm \sigma$ are, respectively, 10, 10, 8 (expected, 10). The large coefficient of variation for trunk — more than one-third as great again as that for head, and well over thrice that for tail — is noteworthy.

Brood pouch. A brood pouch is present, or indicated, in 5 individuals as follows (specimens lettered in ascending order of magnitude of *Ls*). Specimen *(d)*, *Ls* 61.0, not fully developed, a groove along the first 7 caudal

rings; *(f), Ls* 69.5, slit for 9.3 rings (1st ring half only), extending 10 mm; *(m), Ls* 90.3, pouch 18 long, on 8.2 rings, with 12 pairs of embryo eyes visible; *(n), Ls* 91.0, 23 long, on 11.5 rings (very shallow on last ring), with 19 pairs of eyes visible; *(o), Ls* 93.5, 23 long, on 11.7 rings *(i.e.,* here, as in *(n),* about to level of base of dorsal).

Breeding season. Though little published information is available concerning the breeding season of Australian pipefishes it would seem, at any rate in some species, to cover a wide period. Some data on some Tasmanian forms are here summarized. *(i) Syngnathus phillipi* Lucas, 1891: pouch present, perhaps not fully developed 23 July (Part XI, 1963: 17, fig. 5); ovigerous, November, January, February (unpublished). *(ii) Syngnathus curtirostris* Castelnau, 1872: low pouch ridges on 1 of 9 examples, 4-5 August (XIV, 1966:95); ovigerous, November, January, February (unpublished). *(iii) Stigmatopora argus* (Richardson), 1840; ovigerous, January (XI, 1963: 20, fig. 7). *(iv) Lissocampus caudalis* Waite & Hale, 1921: ovigerous, November, January (unpublished). *(v) Ichthyocampus cristatus* McCulloch & Waite, 1918: pouch not fully formed, or in early regression, 20 July (XVII, 1970:36). *(vi) Mitotichthys tuckeri* (Scott), 1942: ovigerous, 4 November 1957 (IX, 1960: 88), ovigerous, November 1965 (unpublished). *(vii) Solegnathus spinosissimus* (Günther), 1870; ovigerous, 4 March, Maroubra, N.S.W., (Waite, 1895: 223). *Solegnathus fasciatus* (Günther), 1870: ovigerous, latter part of November (McCulloch, 1911: 27); ovigerous, 25 June (XI, 1963: 18, figs 6 *a, b, c). (ix) Urocampus carinirostris* Castelnau, 1872, pouch present or indicated in 5 of 15 specimens, April (above). For hippocampids, see Whitley & Allan (1958).

Opercular ridge. In view of the general constancy, through a wide range of species of the presence or absence (and, where present, the nature) of an opercular keel—with a few species, *e.g., Stigmatopora argus* (Richardson), 1840, exhibiting in juveniles a keel that is lost [normally: however, see Part IX (1960: 90)] in adults—and the significance accordingly attached to this feature as a specific criterion, it is indeed surprising to encounter in the present sample no fewer than 12 atypical keels, involving 8 individuals; the abnormality taking the form of a secondary keel (in one instance two such keels), arising as a branch from the primary, usually proceeding caudad (in 3 opercula cephalad), and swinging down away from it. An instance of two supernumerary keels has been reported (Scott, 1966: 93) for *Stigmatopora nigra* Kaup, 1853. For each case in the present material there are noted below, first, the point of origin of the branch, secondly, its approximate length (a gradual lapse to extinction renders difficult a precise determination of the end of some ridges), thirdly, the approximate distance between the terminations of the ridges—each value being expressed as an estimated decimal fraction of the length of the definitive keel, taken as unity.

Specimen *(d), Ls* 61.0, left operculum 0.5, 0.5, 0.3; right 0.6, 0.4, 0.3: *(f), 65.5,* left 0.7, 0.5 *(i.e.,* ending behind primary ridge), 0.25: *(i),* 69.0, left 0.3 (not quite in contact), 0.6, 0.2 (slightly sinuous, net direction almost horizontal): *(j),* 69.5, left 0.5, 0.65, 0.25; right 0.4, 1.0 ('branch' stronger than 'main ridge', the latter slightly convex upward), 0.5: *(k),* 70.4, right 0.5, 0.4, 0.25 (running forward; not strongly developed): *(l),* 75.9, left 0.5, 0.6, 0.3, a short second horizontal ridge 0.55, 0.3, 0.15; right 0.4, 0.35, 0.2 (running forward): *(m),* 90.3, left 0.3, 0.5, 0.3: *(o),* 94.1, left 0.7, 0.3, 0.2 (secondary ridge not well developed); right 0.4, 0.45, 0.25 (running forward; not strongly developed). An operculum 'with two distinct keels which join immediately behind the eye' has been described for *Syngnathus flindersi* (Scott), 1957, from South Australia: no instructed comment is possible without examination of specimens: however, inspection of the figure (1957, fig. 2) would seem to raise a question as to whether the upper ridge may perhaps represent, wholly or in part, an elevated delimitation of the superior border of the opercular plate.

While the typical course of the definitive keel — a downwardly convex curve with its posterior end about level with, or somewhat above, its anterior end — is exhibited, with tolerably fidelity, by 11 opercula, no fewer than 7 variants are to be found in the other 19 opercula, as follows: *(i)* downwardly convex, with anterior end the higher, 7 [*(c)* right; *(e)* right; *(g)* left; *(h)* left; *(k)* right *(l)* right; *(o)* right]; *(ii)* downwardly convex, posterior end unduly high, 5 [*(d)* left; *(f)* left; *(i)* left; *(j)* left; *(m)* left]; *(iii)* virtually straight ,sloping steeply down and back, 1 [*(f),* right]; *(iv)* virtually straight, virtually horizontal, 3 [*(c)* left; *(g)* right; *(n)* right]; *(v)* more or less straight and horizontal for most of length, turning down sharply posteriorly, 1 [*(b)* left]; *(vi)* more or less straight and horizontal for most of length, turning up sharply posteriorly, 1 [*(l)* left]; *(vii)* curving up sharply (convex upward), anteriorly, then running more or less straight and horizontal for most of length, 1 [*(j)* right].

Relative growth. Like the 1965 sample, the present material offers no unequivocal evidence concerning relative growth of head, trunk, tail — such as has been demonstrated in *e.g., Syngnathus curtirostris* Castelnau, 1872, *Mitotichthys tuckeri* (Scott), 1942 (see Scott, 1964: 86; 1965: 59, 1966: 94) — the correlations for lengths of these regions, expressed as millesimals of standard length, with standard length not exhibiting statistical significance ($r = 0.285, 0.012, 0.442$, respectively, all positive; $z = 0.293, 0.012, 0.475$).

Values of Conspectus items. Items of the Conspectus (Scott, 1961: 58) recorded for the present material are: trunk rings 9 (6 specimens), 10 (9); head in trunk 1.91 2.89*, $\bar{x}$ 2.29 $\pm$ 0.07, trunk in tail 3.28*-5.02, $\bar{x}$ 3.96 $\pm$ 0.14: previously recorded ranges of the two body-ratios noted were (1965: 58) 1.58-2.29, 3.42-5.34, respectively, the asterisked values thus extending each of the known ranges at one extreme. A count of 10 trunk annuli, here modal, does not appear to have been recorded for non-Tasmanian material (Munro, 1958: 88). For comparison with Munro's entry, combined head and trunk in tail 2-3, we have here 2.43-3.31, $\bar{x}$ 2.77 $\pm$ 0.07.

Genus **LEPTOICHTHYS** Kaup, 1853

Leptoichthys fistularius Kaup, 1853

Leptoichthys fistularius Kaup, 1853, *Arch. Naturg.* xix, 1:223 *(ex Typus fistularius* Bibron MS). Type locality, King George's Sound, Western Australia.

Regeneration, scute formation. A beach-dried specimen from Tomahawk Island, off Dorset, collected by Miss D. Cassidy in December 1969 (Q.V.M. Reg. No.

1970.5.26) provides an interesting case of what is apparently fin and segment regeneration after injury, and affords some evidence on the probable course of synthesis of the exoskeleton from primary elements here termed, for convenience of exposition, scutella.

In a normal individual of this species the caudal is long (longer, both relatively and absolutely, than in any other Tasmanian — possibly any other Australian — pipefish), its length being twice, or more, that of postorbital head, and subequal to that of the long dorsal base; and the last caudal annulus is longer than any other. In the present example, the caudal, which has the usual 8 rays, is 11, or about seven-tenths of postorbital head (15.5), and a little less than a quarter of dorsal base (44.5); the last complete caudal annulus is 4, the penultimate and antepenultimate being 8, 9, respectively.

In the fully developed exoskeleton each segment has the form of four sides of a box, fused with the preceding and following segments. On the ventral surface the tail appears to be constituted of two (or parts of two; see below) scutella, fused along the median line, the junction being indicated in the anterior half of the tail by a groove, in the posterior half by a ridge, which becomes progressively more distinct caudad: on the trunk there is present an additional scutellum, intercalated between the others, its width exceeding, in places being about double, their combined width; near the middle of its length this median scutellum is briefly expanded on each side in a rounded flap, giving here, and, perhaps less markedly, elsewhere, some indication of the scutellum overlapping its neighbours. On the dorsal surface of both trunk and tail two scutella meet in the midline of each segment, the anterior border of each forwardly convex, the posterior border forwardly concave, the line of junction being traceable, more or less clearly, usually as a shallow groove, at times as a slight ridge. On the lateral surface, the tail, as far forward as the scute immediately behind the base of the dorsal, presents two scutella, lying side by side: however, the dorsal is set on an elevated base, and the region cephalad of the fin termination, comprising 5 caudal rings and all those of the trunk (24), takes on a new character by the introduction of an azygous scutellum, fused above, in rather inconspicuous junction, with the almost straight lower border of the upper scutellum, apparently overlapped below by the strongly upwardly convex upper border of the lower scutellum. Ventrolateral and dorsolateral ridges demarcate the four faces, the former trenchantly developed through the whole postcephalic length of fish; the latter strong on tail, obsolescent on much of trunk. All four surfaces of the tail are more or less flat (the ventral completely so), at least forward to level of dorsal termination, in advance of which lateral and dorsal surfaces exhibit slight rounding. In the trunk the ventral surface is flat, the other surfaces tending towards flatness mesially, but having their borders rounded.

Inspection of the fully established exoskeleton leaves unresolved the question as to whether the angles along which the four surfaces meet represent lines of coalescence of adjoining scutella, or whether the change of direction of the face (enhanced visually by the presence of the ventrolateral and dorsolateral ridges) occurs more or less along the midline of a single scute, each half, or so, of which exists in a different plane. In other words, is the complete annulus a synthesis, on the one hand, in the trunk of 10 scutella [dorsal (1 + 1), lateral 2 (1 + 1 + 1), ventral (1 + 1] and in the tail of 8 [dorsal (1 + 1), lateral 2 (1 + 1), ventral (1 + 1)], or on the other hand, in the trunk of 6 scutella [dorsal ($\frac{1}{2}$ + $\frac{1}{2}$), lateral 2 ($\frac{1}{2}$ + 1 + $\frac{1}{2}$), ventral ($\frac{1}{2}$ + $\frac{1}{2}$)], and in the tail of 4 [dorsal ($\frac{1}{2}$ + $\frac{1}{2}$), lateral 2 ($\frac{1}{2}$ + $\frac{1}{2}$), ventral ($\frac{1}{2}$ + $\frac{1}{2}$)]? Light is cast on the matter by an examination in the present specimen of the regenerating region just anterior to the caudal fin, where the development of the definitive scute is to be seen in progress. On the left lateral aspect two leaflike scutella, each about 4 long, rather less than one-third as wide, lie side by side longitudinally, their inwardly convex borders separated by a fontanelle occupied by a deep depression, the greatest width of which, at either end, approximates the greatest width (as exposed on ventral surface) of a single scutellum. This depression continues forward very briefly, partly to separate the rounded posterior ends of the scutella of the adjoining segment, the upper being overlapped by the upper scutellum of the developing segment, the lower being more or less fully fused with its partner. On the right lateral aspect the position is similar, except that here the ends of both scutella of the penultimate segment are overlapped. On the dorsal surface, what are clearly extensions (dorsad and mediad) of the developing scutella of the lateral surface curve inward from lateral ridge, but fail to meet in the mesial line, where their margins, only slightly convex inwards, are separated by a deep steep-sided groove, the width of which is, at the middle of their length, a trifle greater, at their ends a trifle less, than the width of the groove on the ventral surface. On the ventral surface, the margins of the scutella have wholly fused, though indications of their existence remain in the form of closely apposed ridges, extending for almost their entire length; again there are no signs of scutellum division at the tail angles.

The evidence afforded by these regenerating elements that scute synthesis in the tail is of the form ($\frac{1}{2}$ + $\frac{1}{2}$) receives support from still smaller rudiments lying behind those already described. Adjoining each of the latter, and extending back on to actual caudal base, there is at each interface angle an incipient scute, subtriangular or pyriform, which, on close examination, is found to have part of its small area in the lateral surface and part on either the dorsal or the ventral surface. In all these rudiments the course of the ventrolateral or dorsoventral ridge can be traced; with, however, some change of direction, coming to lie more on the lateral than on the dorsal or ventral face, possibly being pushed aside by the expanded bases of the uppermost and lowermost caudal rays, which extend between, and well cephalad of, them. In spite of their small size these scute elements are strongly sculptured, bearing the interfacial ridge and several longitudinal curved striae, separated by grooves. In the larger developing scutella just in front of them the general sculpture pattern of the normal lateral scute — an intricate system of grooves, striae (either continuous lines, or, more commonly, made up of closely set, or contiguous, or basally confluent minute mounds), and small mammilliform elevations — is almost fully established.

This specimen provides the second published record of this species in Tasmania, the first, based also on a beach-dried example, having been noted in Part IV of these Observations (1939).

Present length, with most of snout missing, 398; trunk 191; tail 172; eye 6.7; postorbital head 44.5; caudal 11. Annuli 24 + 20; suborsal 3.0 + 4.6. D.36. P.21/22. C.8. A.4, minute.

Genus **LISSOCAMPUS** Waite & Hale, 1921

Lissocampus caudalis Waite & Hale, 1921

Lissocampus caudalis Waite & Hale, 1921, *Rec. S. Aust. Mus.*, 1, 4: 306, fig. 46. Type locality, Kangaroo Island, South Australia.

Locality record. The first record for Tasmania (Scott, 1961: 61) was based on 3 specimens from Fisher Island, Bass Strait, collected by Mr B. C. Mollison: the species has not hitherto been formally recorded from the Tasmanian mainland, but now may be, 2 examples having been collected by Mr R. H. Green at Green's Beach, Devon, in January, 1969.

Disposition of ova. Though the brood pouch of this species has been figured by the writer (1961, fig 3 d), no account of the disposition of the ova appears to be available. In the smaller individual the marsupium extends over the first 15 caudal rings, occupying 0.28 length of tail. Viewed from the left side, it presents a proximal row of 13 pronounced bulges, of which 2 at either end are free, the remaining 9 being capped by a distal row of 12: of the 2 anterior separate bullae, the second rises much higher than the first, reaching well above level of base of external series; the 2 posterior free items are subequal in height, a little taller than the first of the anterior pair. On the right side the arrangement, proceeding caudad, is: low free bulla; high free bulla, reaching to halfway up the distal row; 9 proximal, surmounted by 11 distal; one very high, extending right to outer margin of distal row; a pair of moderate-sized proximal bulges, capped by a pair of equal-sized distal ones; a single moderate proximal item. The ova, modally about 1.7 long, with modal transverse extent as they lie close together in pouch of about 1.2, number 43. In the bottom (internal) layer they are arranged thus: 1 + 1 + 9 (2) + 1 + 1 = 22; in the top layer 0 + 10 (2) + 1 = 21. Embryo white, yolk sac yellow. Total length of embryo, straightened out, about 4; head 1.1; eye 0.4, about twice length of snout, which is relatively very wide, moderately pigmented.

Counts, dimensions. The ovigerous individual is cited first. Annuli 11 + 54; 11 + ?55. Subdorsal annuli: from 0.9 of penultimate body ring to 0.2 of second caudal ring = 2.3; from 0.0 of last body to 0.2 of second caudal = 2.2. D. about 11; 12. C. 10; 10. P. 5/6; 6/6. A. not seen; short, broad, 3 lobes, each with a ray. Head 5.5; 7.0. Snout 2.0; 2.5. Eye 1.0; 0.9. Interorbital 0.9; 1.1. Length of pectoral 1.6; 1.7. Length to dorsal origin 18.4; 21.0, base 2.0; 1.9. Length to vent 19.1; 21.5. Length to front of pouch 19.8, to end 37.4. *Ls* 75.0; 76.1. *Lt* 76.2; 77.8.

Synopsis entries. The material provides values that represent one or more new extremes for 4 of the 11 items recorded in the Synopsis of Tasmanian syngnathids (1961:58), as follows: annuli now 11-12 + 54-60 (formerly 12 + 56-60); subdorsal 1.1 + 2.0 (0.2 + 2.0); snout in head 2.7-3.4 (2.7-3.1); head in trunk 2.1-2.6 (2.2-2.6).

Comparison with Fisher Island material. While it is not proposed here to institute a comprehensive comparison of the metrical characters of the earlier sample and the present one, half a dozen dimensions, calculated as thousandths of total length, may profitably be collated. Entries below are arranged with specimens in ascending order of *Lt* (for Fisher Island specimens, *Lt* 100.5 (male), 91.0, 68.0). Trunk 163, 179, 186, 180, 165. Length to dorsal origin 232, 241, 270, 241, 222. Dorsal base 29, 26, 24, 29, 28. Length of pectoral 21, 21, 22, 20, 19. Length of caudal 21, 16, 22, 23, 19. Length of brood pouch 231, 259.

Family NANNOPERCIDAE

The small endemic Australian freshwater fishes now generally placed by local authors—*e.g.*, Munro (1961), Scott (1962) — in the family Nannopercidae have been (and continue to be) moved round among a number of families, for example, Percidae (Johnston, 1891), Centrarchidae (McCulloch & Waite, 1918; Waite, 1921), Kuhlidae (McCulloch, 1927; Greenwood, Rosen, Weitzman & Myers, 1966), Hyperlectrodidae (McCulloch, 1929), Serranidae (Lord, 1923; Lord & Scott, 1924; Berg, 1940), Nannatherinidae (Whitley, 1960).

Of the general *Nannoperca* Günther, 1861, *Paradules* Klunzinger, 1872, *Microperca* Castelnau, 1872, *Edelia* Castelnau, 1873, the first and last only are now generally recognized (Whitley, 1960; Munro, 1961); the former of these having the preorbital rounded and entire, the latter with it angular and serrated.

Four species, all referred to *Nannoperca,* are recognized in the Check-List (McCulloch, 1929): (1) *N. australis* Günther, 1861, type locality, Murray River (synonyms, *Paradules leetus* Klunzinger, 1872 — emended in 1879 by Klunzinger to *P. laetus* — type locality, Murray River; and ? *N. riverinae* Macleay, 1881, type locality, Murrumbidgee River); (2) *N. tasmaniae* (Johnston), 1883, type locality, River Esk, Tasmania; (3) *N. obscura* (Klunzinger), 1872, type locality, Yarra lagoon, Victoria (synonym, *Microperca yarrae* Castelnau, 1872, type locality, Lower Yarra River, Victoria); (4) *N. vittata* (Castelnau), 1872, type locality, freshwater, interior of Western Australia (synonym *Edelia viridis* Castelnau, type locality, freshwater, interior of King George's Sound, Western Australia).

In their review of the family, McCulloch & Waite (1918) treat *Nannoperca* and *Edelia* as subgenera (of *Nannoperca). N. australis* and *N. tasmaniae* are regarded as specifically distinct; but are not distinguished between in their key (p. 45). Waite later (1921) listed Johnston's species as a queried synonym of Günther's: short notices by the present writer (1935: 66; 1942: 48) failed to provide any criteria for differentiating between them. In their 1918 paper Waite & Hale remark 'Günther's original account of *Nannoperca* included some important errors which have caused some confusion: he observed no lateral line, whereas his figure shows a very distinct canal, which, however, is quite different from what is actually found in the genus'.

Referring (3) and (4) to *Edelia,* Munro (1961) recognized in *Nannoperca* two species: *N. oxleyana* Whitley,

1940, range, fresh waters on Moreton Island, Queensland, and Richmond River, northern New South Wales; *N. australis* with two subspecies, *N. australis australis* Günther, 1861, Murray-Darling system, New South Wales and South Australia, and coastal streams, southern Victoria, and *N. australis tasmaniae* (Johnston), 1883, Tasmania and King Island. [While King Island and Flinders Island are each, politically, part of the State of Tasmania which is itself politically part of Australia, the convenient convention is here adopted by speaking of Tasmania, King Island, (county of same name), Flinders Island, county of Flinders, and Australia, without qualification, as four distinct and independent localities. The Flinders Island here mentioned is the largest island of the Furneaux Group, in Bass Strait, off the northeastern corner of the island of Tasmania: a second, much smaller Flinders Island lies off the west of Eyre Peninsula, South Australia]. Species (3) and (4) of the Check-List series are referred to *Edelia*.

The present paper reports the results of an examination of 7 specimens of *N. australis*, 15 specimens of *N. tasmaniae*, 2 fish from King Island *(N. tasmaniae?)*, and 4 fish from Flinders Island — the last-named being nominated as the types of *Nannoperca australis flindersi subsp. nov.*

Genus **NANNOPERCA** Günther, 1861

Nannoperca australis Günther, 1861

Nannoperca australis flindersi subsp. nov.

Description. Body oblong, compressed. Greatest depth 2.8-2.9, depth at vent 3.3-3.6, head 2.8-2.9, in standard length. Eye 3.6-3.9 in head; greater than, 1.16-2.29, snout; equal to, or less than (0.92-0.98), interorbital. Jaws equal. Maxilla with supplemental bone; fails to reach level of eye by 0.1-0.15 eye-diameter. Narrow bands of villiform teeth in jaws and on vomer. Preorbital entire, rounded. Preoperculum entire. Operculum with a double spine or two closely apposed spines; flat; not projecting beyond membranous border. Anterior nostril a short tube, its diameter exceeding its height, the opening subcircular; about equidistant from orbit and preorbital border. Posterior nostril a simple oblique elliptical opening, close to orbit at, or slightly behind, level of front of pupil. Open pores on top of head, along upper part of operculum, around preoperculum, on mandible. D. vii; i; 10; a deep notch, extending down almost to trunk, between spinous and soft portions; length to origin of fin 454-470 *TLs;* length to termination of spinous portion 599-630, of soft portion 767-791; 2nd spine longest (1.02-1.12 3rd, 2.1-2.5 spine of second dorsal, 2.2-2.5 in head). A. iii, 8; originating at 640-673, terminating at 807-824 *TLs;* 3rd spine slightly longer than (1.02-1.06) 2nd, 1.7-2.0 1st, 3.1-3.4 in head. Pectoral 11-12; inserted in advance of ventrals, at 0.85-0.89 of length to latter; longest ray (6th) 1.9-2.2 in head; longer than 3rd dorsal spine. V. i, 5; inserted at 380-390 *TLs;* whole fin, longest (2nd) ray, spine 1.7-1.9, 1.9-2.3, 3.1-3.5, respectively, in head. Caudal with 17-18 main rays; rounded; its length, from hypural joint, 5.1-5.4 in rest of fish. Scales ciliated; covering whole of body, operculum, cheek, dorsum of head from level of first pair of pores caudad of posterior nostrils to a variable point between pores and nostrils Scales from shoulder to hypural joint 30-31; 2-3 on caudal base. Transverse scales $2\frac{1}{2}$ + ($9\frac{1}{2}$-$10\frac{1}{2}$). Predorsal scales becoming smaller and confused on dorsum of head; *ca.* 18-21. Lateral line represented by two series of tubules, upper terminating near, lower originating near, level of dorsal notch; but pattern may differ on the two sides of the fish, and part, or all, of a series may be missing; upper line with 0-8, lower with 0-6 tubules (in types, means 5.1, 3.6). Gillrakes on anterior arch (2 + 8-9).

Coloration, after preservation in alcohol. Lateral surface of trunk and tail above the general sense of a line from pectoral base to near end of anal dark olivaceous brown, tending to be darker anteriorly, darkening also near the superior profile to merge with the dorsal surface, which approaches black; numerous irregular dark patches and mottling of various sizes, one constant dark area occurring above pectoral base; no clear indication of presence of dark horizontal bands on body (or head): flank below the olivaceous brown, belly, throat pale yellowish, immaculate or with a few small dusky smudges: some 6-12 heavily pigmented scales at base of caudal, modally forming a rather distinct dark spot, at times reduced to a somewhat obscure darkish bar. The light yellowish of the lower flank continuing forward over the head, increasing in vertical extent to reach about lower border of orbit; variably mottled with brownish and blackish, the most discrete markings a series of 4-6 spokes at border of operculum; above light region, darkening more or less rapidly to become black or bluish black on dorsum of head; lower lip dark mesially, lightening, usually very markedly, laterally; upper lip with more extensive, and in general rather deeper, darkening. First dorsal rather dark olivaceous or brownish, the spines slightly darker than the membrane. Rays of second dorsal varying from light to dark brownish; first ray, or first few rays, sometimes also distal half, or so, of some succeeding rays darker than the rest; membrane ranging from colourless to pale brownish and/or bluish. Anal proximally whitish, distally brownish, usually becoming, especially in anterior part of fin, black: in 3 individuals most anal rays ranging, after brief proximal whitish portion, from black to blackish brown posteriorly, membrane mostly brownish; in 1 individual (female?) the same colour pattern appears but the coloration is very much less intense. Pectoral pale, the rays outlined very slenderly with blackish; base with yellowish and pale brownish areas, variable in extent, either region with or without brownish punctulations. Ventral briefly whitish basally, whitish to a variable extent on inner rays, otherwise dark brown and/or black; in largest specimen (? female) white, with faint duskiness along one or two inner rays. Caudal rays pale greenish or yellowish green, with darker, brownish borders, finely peppered with reddish; membrane hyaline, with minute reddish punctuations, best developed in a strip along the middle, or in two strips along the sides, of each interradial membrane slip.

Affinities. The Flinders Island fish differs trenchantly from *N. oxleyana* Whitley, 1940, from Queensland and New South Wales *(i)* in possessing a lateral line, *(ii)* in having 30-31, instead of 25, scales in longitudinal series, *(iii)* in lacking the conspicuous orange-edged black ocellus at caudal base. It is clearly to be regarded as a subspecies of *N. australis.*

It is readily distinguishable from both *N. a. australis* Günther, 1861 and *N. a. tasmaniae* (Johnston), 1883 by the fact that the maxilla (which possesses the characteristic supplemental bone) fails to reach level of orbit (by 0.1-0.15 eye-diameter), while extending in the other forms beyond orbit. With the dimensions length to termination of first dorsal, length to origin of anal expressed as millesimals of standard length, we find *(i)* in *N. a. australis* the mean of the former is significantly greater ($t = 2.23$*) than the mean of the latter (means are recorded in table 1); *(ii)* in *N. a. tasmaniae* the means are equal (their exact equivalence being of course a sampling accident); *(iii)* in *N. a. flindersi* the mean of the latter is significantly the greater ($t = 4.45$**). In the 2 fish from King Island (referable, on current views — *cf.* Munro (1956: 155)—to the Tasmanian subspecies) the position is as in the Australian subspecies, but the means are not significantly different ($t = 2.84$), nor is there a significant difference between the anal origin means of the King Island and Tasmanian samples ($t = 1.12$).

A number of proportional differences between the Flinders Island specimens and the examined material from other sources are summarized in table 2. This records a series of features for each of which there exists a significant difference between the mean values in one pair, or more than pair, among the four samples (taking into account all six two-locality combinations); t values and their significance being reported, and an indication being given as to which sample has the higher mean in each locality pair. Of the 13 characters, the first 7 are calculated from *TLs* values, the remainder (all ratios) are calculated directly from measurements (mm). It will be seen that statistically acceptable differences between the Tasmanian and Flinders Island sample means are found in 11 instances; between the Australian and Flinders Island sample means in 5.

N. a. australis is described by Munro as having '2 distinct horizontal bands, lower continued on to snout', and *N. a. tasmaniae* as having 'irregular dark patches scarcely forming two horizontal bands except on head' (in our Tasmanian material there is usually a tolerably clear indication of one band, more or less continuous or considerably interrupted, extending from eye back along head, and along flank at least to a point somewhere below dorsal base, not infrequently continuing on to caudal peduncle). No such markings are apparent in the Flinders Island fish. The dark spot or bar at caudal base in this subspecies, described above, is detectable in most of the Australian and Tasmanian specimens, but in a more diffuse decidedly less conspicuous form.

Dimensions as TLs. A series of dimensions for the sample of *N. a. flindersi*, expressed as thousandths of standard length, is set out, along with the corresponding entries for the samples of *N. a. australis* and *N. a. tasmaniae* (together with the values for the 2 King Island fish) in table 1, range, mean, standard deviation and coefficient of variation, the last three accompanied by their standard errors, being reported (standard deviation calculated from $\sigma = \sqrt{\frac{\Sigma (x - \bar{x})^2}{N}}$

Types. Described from 4 specimens, standard lengths 44.9, 49.1, 33.2, 37.4 mm, from Lackrana, Flinders Island Furneaux Group, Bass Strait, collected by Masters P., R., and C. Rhodes, 1 September 1969. The second largest individual is designated as holotype, the others as paratypes. Holotype and one paratype deposited in the Queen Victoria Museum, Launceston (Reg. No. 1970.5.25). One paratype will be offered to the British Museum (Natural History), London, one to the Australian Museum, Sydney.

The subspecific name is in honour of Matthew Flinders (1774-1814), who made a survey of the Furneaux Islands in 1798.

Nannoperca australis australis Günther, 1861

Nannoperca australis Günther, 1861, *Proc. Zool. Soc. Lond.*: 116, pl. xix, fig. 2. Type locality, Murray River.

Material. The material used in the present investigation has been made available by courtesy of the Director, South Australian Museum, Adelaide, through the kind offices of Mr C. J. M. Glover, Ichthyologist at that institution. The data on the labels may be summarized as follows. Specimen *(a)*, *Ls* 52.1, *Lt* 63.7; locality, Narrandera, Murrumbidgee River, N.S.W.; November 1919; Reg. No. F. 573 (originally Aust. Mus. I. 13593, part); a second label, also giving the Aust. Mus. number, notes 'Figured specimen' [probably that depicted in the illustration (pl. II, fig. 1)] accompanying the synoptic account of *Nannoperca* by McCulloch & Waite (1918), who note (p. 46) 'The specimen figured is 65 mm. long and was taken near Narrandera, on the Murrumbidgee River, New South Wales'. Specimens *(b)*, *(c)*, *Ls* 47.2, 43.9: South Australia; collector Geisler; 14/8/17; Reg. No. F.446; a second label records 'placed in upstairs aquarium Aug. 14th 1917. Died Dec. 5th 1918'. Specimens *(d)-(g)*, *Ls* 35.0, 34.9, 32.0, 29.6: Murray River, South Australia; collector P. A. Geisler; 1915. Reg. No. F.57. All primary labels record the determination is by C. J. M. Glover. Throughout the present investigation this material is designated simply as Australian.

Dimensions as TLs. These are recorded in table 1.

Comparison with other material examined. See tables 1, 2; also discussion above on affinities of *N. a. flindersi*.

Comparison with Handbook diagnosis. Comparison of specifications of the material here examined with the diagnosis of the subspecies given in the Handbook (Munro, 1961: 154, fig. 941 [figure reproduced from McCulloch & Waite, 1918]) reveals in general good agreement. However, some differences are found, as follows (Handbook diagnosis first, followed, after semicolon, by specification of present sample). Depth in *Ls* 3.2-3.6; 3.0-4.4, $\bar{x}$ 3.45 $\pm$ 0.13. Head in *Ls* 3; 2.8-3.0, $\bar{x}$ 2.96 $\pm$ 0.03. Eye in head 3.8-4; 3.4-4.0, $\bar{x}$ 3.66 $\pm$ 0.08. 'Eye slightly greater than snout'; snout 1.0-1.4 $\bar{x}$ 1.23 $\pm$ 0.05 in eye. 'Eye less than interorbital'; eye ranging from less than (0.93) to greater than, 1.32), averaging greater than (1.08 $\pm$ 0.05) interorbital: see discussion of this ratio below. D. vii; i, 8-9; D. vi-vii; i, 9-10 (4 specimens with vii; i, 9: 1 each with vi; 1, 9: vi; i, 10). Maxilla reaches 'to below front of pupil'; to 0.05-0.2 $\bar{x}$ 0.15 $\pm$ 0.02 of eye.

Additional specifications. A. iii, 6-8 (in agreement with Handbook), 2 examples with 6 rays, 3 with 7, 2 with 8. With both dimensions expressed as *TLs,* mean length to anal origin is in this material significantly less than mean length to last spine of first dorsal (see above, discussion of affinities of *N. a. flindersi);* and the former dimension is here less (table 1), and significantly less (table 2) than in the Tasmanian, the Flinders Island, and the King Island samples.

Nannoperca australis tasmaniae (Johnston), 1883.

Microperca tasmaniae Johnston, 1883, *Pap. Proc. Roy. Soc. Tasm.* (1882): 110 Type locality, R. Esk, Tasmania.

Material. 15 examples from a series collected by Mr R. H. Green and Mr R. Vogelpoel on 21 January 1962 in a swamp about 2 miles south-west of Tullendena.

Dimensions as TLs. See table 1.

Comparison with other material examined. See tables 1, 2; also discussion above on affinities of *N. a. flindersi.*

Comparison with Handbook diagnosis. Comparison of the specifications of the material here examined with the diagnosis of the subspecies given in the Handbook (Munro, 1961; 154, fig. 942) — figure, rather poor, a sketch by R. M. Johnston of his *Microperca tasmaniae,* reproduced by Whitley (1929, pl. III, fig. 1) in his redaction of Johnston's notebooks — reveals general agreement: certain differences are noted below (Handbook diagnosis first, followed, after semicolon, by present data). Depth in *Ls* 3.4-3.5; 2.8-3.3, $\bar{x}$ 3.03 $\pm$ 0.03. Head in *Ls* 3-3.4; 2.9-3.2, $\bar{x}$ 3.08 $\pm$ 0.03. Eye in head 3-3.5; 3.3-3.8, $\bar{x}$ 3.61 $\pm$ 0.01. Eye 'greater than snout'; eye 1.2-1.5, $\bar{x}$ 1.33 $\pm$ 0.004 snout. Eye greater than interorbital; eye less than (0.80-0.99, $\bar{x}$ 0.92 $\pm$ 0.02) interorbital: see discussion of this ratio below. Maxilla reaches 'to below front of pupil'; to 0.2-0.3, $\bar{x}$ 0.22 $\pm$ 0.03 of eye, or from about half to end of prepupillary eye. D. vii-viii; i, 7-9; D. vi-viii; i, 9-10, the distribution being vi; i, 9 (7 specimens), vi; i, 10 (5), vii; i, 9 (2), vii; i, 10 (1). A. iii, 7-8; A. iii, 7-10, the distribution being iii, 7 (5), iii, 8 (9), iii, 10 (1).

Additional specifications. With both dimensions expressed as *TLs,* mean length to anal origin is equal to mean length to last spine of first dorsal (use of raw measurements gives their ratio as 0.99): contrast *N. a. australis* (first dimension the lesser) and *N. a. flindersi* (first dimension the greater). For a note on coloration in this subspecies, see discussion, above, of affinities of the Flinders Island form.

Relative growth. Predictably, there exists a significant negative correlation ($r = -0.79$, $z = 1.08$, $t = 4.65$**) between relative diameter of eye *(TLs)* and *Ls.*

Of the 8 simple dimensions *(TLs)* appearing in table 2, 2 exhibit a significant correlation, in each case a negative one, with *Ls,* namely, length to termination of first dorsal ($r = -0.60$, $z = 0.69$, $t = 2.71$*), and length to origin of anal ($r = -0.67$, $z = 0.81$, $t = 3.23$**): the two dimensions are themselves positively correlated at $r = +0.60$, $z = 0.69$, $t = 2.69$.* Differences between sample *Ls* means are not large — the means being Australia 39.2, Tasmania 44.99, Flinders Island 38.65, King Island 32.0. The unfortunate numerical smallness of the samples precludes the drawing of a wholly satisfactory conclusion: on the available evidence, however, the differences in relative positions of first dorsal termination and anal origin to which attention has earlier been called may well represent a genuine point of distinction.

Distribution. The distribution of Johnston's fish was originally noted as rivers in northern Tasmania, this species (like *Gadopsis marmoratus* Richardson, 1845, of the strictly Australian family Gadopsidae) occurring, in this State, only in waters discharging into Bass Strait. Some five years after its description, however, Johnston himself (1888: 74) reported it from King Island also (Yellow Rock Creek). King Island examples are treated in the Handbook as *N. a. tasmaniae.* Two specimens from King Island, collected at Pass River on 13 March 1970 by Mr M. T. Templeton, that came to hand after the present investigation was begun exhibit some differences from the fish of our Tasmanian sample that seem worthy of being reported.

King Island specimens. Inspection of table 2 shows that, of the 13 features dealt with, there are 4 for which the mean values of the Tasmanian and King Island samples are significantly different. The King Island values for these are: interorbital, as *TLs,* 72-86, $\bar{x}$ 79.0 $\pm$ 4.70 (*cf.* Tasmania 87-108, $\bar{x}$ 99.0 $\pm$ 1.6); interorbital in eye 1.3-1.3, $\bar{x}$ 1.29 $\pm$ 0.02 (cf. 0.80-0.99 $\bar{x}$ 0.92 $\pm$ 0.02); eye in head 3.1-3.2 $\bar{x}$ 3.19 $\pm$ 0.02 (*cf.* 3.3-3.8, $\bar{x}$ 3.61 $\pm$ 0.01); maximum depth in *Ls* 3.2-3.6, $\bar{x}$ 3.41 $\pm$ 0.12 (*cf.* 2.8-3.3 $\bar{x}$ 3.03 $\pm$ 0.03). With both dimensions expressed as *TLs,* mean length to anal origin exceeds length to first dorsal termination (Tasmania; these dimensions equal), but the difference between them is not statistically significant ($t = 2.84$); nor is the difference of the means of either of these dimensions, as between the examples from the two localities significantly large ($t = 1.22$, 0.83, respectively). The difference of *TLs* means of length of snout in King Island and Tasmanian samples is highly significant ($t = 3.14$**). Differences in length of some fin rays and spines in table 1 are probably to be regarded as of little, if any, diagnostic significance

In coloration the King Island fish differ from our Tasmanian fish in having anterior one-third, or rather more, of spinous dorsal, tips of rays of soft dorsal, anterior one or two anal rays and tips of the others, wholly black, the Tasmanian examples examined having these regions either pale and uniform with the other parts of the fin, or distinguished from them by being somewhat darker, olivaceous or brownish, without trace of black. In the larger individual the whole dorsal surface and the upper half of the sides of the snout, the lips, the interorbital, and the occiput are black; in the smaller the black is confined to the lower lip and to a narrow region bordering the orbit, forming a band, about one-fifth as wide at its maximum as total interorbital width, and continuing, progressively narrowing, round most of eye: this black is not present in the Tasmanian material.

It is evidently desirable that a detailed comparison should be made of long series of specimens from King Island and Tasmania; the material from each source preferably including subseries from different localities: till this is done the status of the King Island *Nannoperca* must remain uncertain.

SUBSPECIFIC DIFFERENTIAE: INTERPRETATION OF PRESENT RESULTS

Some consideration needs here to be given to the significance to be attached, first to certain characters employed as subspecific differentiae; secondly, to the results, some somewhat unexpected, of the present inquiry.

Factors that call for comment are *(i)* degree of extension of the maxillary; *(ii)* eye relative to interorbital; *(iii)* number of dorsal spines and rays; *(iv)* relative location along anteroposterior axis of fish of termination of first dorsal and origin of anal; *(v)* coloration. *(i)* McCulloch & Waite, who treated the Australian and Tasmanian fish as distinct species (without, however, separating them in their key), note of both (1918: 45) 'maxillary reaching to below orbital margin', and their figure (of *N. australis*) shows it reaching about halfway to pupil; the Handbook specifies for each of the two subspecies recognized by Munro 'to below front of pupil'; in all our Australian examples it reaches past orbital margin from one-sixth to half the distance to pupil; in our Tasmanian material from about one-third of distance to pupil right to front of pupil. Also, in *N. oxleyana* Whitley it extends 'to below anterior part of eye.' It would seem, therefore, the failure of the maxilla in the Flinders Island fish to reach as far as orbital margin (by at least 0.1 eye-diameter) satisfactorily differentiates this form at the suggested subspecific level. *(ii)* Günther's original description of *N. australis* as given in Macleay (1881: 392), states 'The eye is much wider than the interorbital space'. Apart perhaps from coloration, the feature, diameter of eye relative to width of interorbital, provides, in the Handbook diagnoses, the only trenchant difference between *N. a. australis* and *N. a. tasmaniae,* the former being described as having eye less than, the latter greater than, interorbital: however, in our Australian material eye ranges from less than (0.93) to greater than (1.32), averaging greater than (1.08 $\pm$ 0.05) interorbital, while in our Tasmanian sample eye, instead of being greater than, is less than (0.80-0.99, $\bar{x}$ 0.92 $\pm$ 0.02) interorbital. It may be observed that in *N. riverinae* Macleay, 1881 (type locality, Murrumbidgee River) the eye is reported as less than distance between orbits. McCulloch & Waite (1918: 341) state 'Macleay later regarded his *N. riverinae* as synonymic with *P. laetus*', adding 'although according to his scale counts ['L. lat. about 24'] the identity would seem improbable: since however, the type of his species is not now to be found his opinion must be accepted.' Both Macleay's and Klunzinger's species are read by them as synonyms of *N. australis* (Macleay's with a question mark), a course followed in the Check-List: they are now conventionally subsumed definitively in Günther's species (*cf.* Munro, 1961; Whitley, 1960, 1964). [In passing, could Macleay's species, with its lateral line count of 'about 24', possibly be *N. oxleyana* Whitley, with 25?]. The marked differences in respect of the eye-orbit ratio here disclosed must raise the important issue of the significance to be attached to this criterion: is some difference in measuring procedure involved; or is the character less constant than hitherto assumed, varying perhaps in different localities within the presumed subspecific region? *(iii)* Though the Handbook gives dorsal formula for *N. a. australis* as vii, i, 8-9, and that for *N. a. tasmaniae* as vii-viii; i, 7-9, McCulloch & Waite earlier gave a minimum count for first dorsal of vi; while our counts for the two subspecies, recorded above, are vi-vii; i, 9-10 and vi-viii, respectively: for *N. a. flindersi* we find D. vii; i, 10, and for the 2 King Island fish D. vii; i, 9-10. *(iv)* The differences here found in relative length, as *TLs,* between termination of first dorsal and origin of anal — values equal in *N. a. tasmaniae,* mean length to anal origin the lesser value in *N. a. australis,* the greater in *N. a. flindersi* — are in part of statistical validity only. The greater value for length to first dorsal termination occurs in 6 of 15 Tasmanian fish; in 5 of 7 Australian fish (with values equal in one specimen); in no one of the 4 Flinders Island fish, the feature thus in this instance being a constant one *(v).* In general, coloration in the samples here examined conforms with the brief accounts in the Handbook; attention may be called, however, to some points of difference between the Tasmanian and King Island specimens, noticed above in account of the latter.

It will have been observed that the samples here dealt with are decidedly small numerically; and the statistical procedures to which they have been subjected may well seem on the face of it to be unduly elaborate: it is possible indeed that such is the case. However, it was early found that tests of significance of difference of means of several characters commonly regarded as of diagnostic value yielded statistically significant results. Calculations covering a number of other features were accordingly made: in view of the consistency of these and the earlier computations, it has been thought expedient to report the data in full; the more so that attempts to secure additional material have remained hitherto unsuccessful.

An instructive indication of the approximation to the normal frequency distribution (a condition for the appropriate employment of the statistical methods adopted) exhibited by the features studied is afforded by an examination of the number of variates lying within the range $\bar{x} \pm \sigma$ (in normal distribution 68%). Taking the 33 *TLs* entries in table 1, we find for 7 Australian specimens the number of cases within $\bar{x} \pm \sigma$ is 3 (2 cases), 4 (10), 5 (16), 6 (1), with an average of 4.6 (expected, 4.8) [29 items only in this sample based on 7 specimens: of the remaining 4 entries including one or more imperfect individuals, 2 have 3 (expected, 4), 1 has 4 (expected, 4), 1 has 3 (expected, 3)]: for 15 Tasmanian specimens we find 8 (1), 9 (6), 10 (10), 11 (10), 12 (5), 13 (1), with an average of 10.5 (expected, 10.3); for 4 Flinders Island specimens 2 (12), 3 (20), 4 (1), with an average of 2.7 (expected, 2.7).

It is evident that though this inquiry is tolerably intensive, it remains, unavoidably, far from being extensive. In view of the fact that some of the results arrived at are not consonant with those already in the literature, the present contribution is not to be regarded as being in any respect a definitive treatment of the problem of subspecies of *Nannoperca australis,* but as essentially a basis for further investigation carried out with large samples, preferably from several localities within each presumed subspecific region. However, as observed above, the distinctness of *N. a. flindersi* would appear to be valid.

TABLE 1

Nannoperca australis Günther, 1861. Statistics of certain dimensions, expressed as millesimals of standard length of 4 samples: A. Australia, *N.a. australis* Gunther (7 specimens); B. Tasmania, *N.a. tasmaniae* (Johnston), 1883 (15); C. Flinders Island, *N.a. flindersi subsp. nov.* (4); D. King Island, *N.a. tasmaniae* (Johnston), 1883? (2).

Feature	Sample	Range	Mean	Standard deviation	Coefficient of variation
Standard length	A	29.6-52.1	39.24±2.97	7.85±2.10	20.0±5.4
	B	35.1-55.8	44.99±1.22	4.73±0.86	10.5±1.9
	C	32.4-44.9	38.65±2.93	5.86±2.07	15.2±5.5
	D	29.0-35.0			
Total length	A[1]	1203-1250	1227.3±7.1	17.5±5.0	1.4±0.4
	B	1206-1311	1247.0±7.3	28.4±5.2	2.3±0.4
	C	1225-1247	1237.3±4.0	8.1±2.9	6.5±2.3
	D	1230-1240			
Length to origin of first dorsal	A	453-496	471.0±5.4	14.3±3.8	3.0±0.8
	B	450-508	477.8±4.2	16.4±3.0	3.4±0.6
	C	454-470	459.8±3.3	6.6±2.3	1.4±0.5
	D	455-460			
Length to termination of first dorsal	A	605-647	626.9±5.7	15.2±4.1	2.4±0.6
	B	618-681	643.8±4.3	16.8±3.1	2.6±0.5
	C	599-630	615.0±6.3	12.5±4.4	2.0±0.7
	D	631-640			
Length to origin of second dorsal	A	622-659	641.3±5.4	14.2±3.8	2.2±0.6
	B	645-701	667.2±4.1	15.8±2.9	2.4±0.4
	C	619-654	637.5±6.8	18.5±4.8	2.1±0.7
	D	657-657			
Length to termination of second dorsal	A	733-794	760.6±6.9	18.2±4.9	2.4±0.4
	B	744-804	775.7±4.3	16.5±3.0	2.1±0.4
	C	767-791	780.0±4.9	9.9±3.5	1.3±0.4
	D	786-797			
Length to origin of anal	A	596-625	610.6±3.6	9.4±2.5	1.5±0.4
	B	605-670	643.8±3.7	14.2±2.6	2.2±0.4
	C	640-673	662.3±6.7	13.5±4.8	2.0±0.7
	D	655-657			
Length to termination of anal	A	746-811	773.7±7.8	20.7±5.5	2.7±0.7
	B	753-813	784.5±4.6	17.7±3.2	2.3±0.4
	C	807-824	813.8±3.2	6.4±2.3	0.8±0.2
	D	810-811			
Length to origin of ventral	A	364-392	373.4±3.3	8.8±2.3	2.3±0.6
	B	325-398	364.3±5.0	19.5±3.6	5.3±1.0
	C	380-395	389.0±2.9	5.8±2.1	1.5±0.5
	D	381-400			
Length to origin of pectoral	A	315-363	336.4±5.3	14.1±3.8	4.2±1.1
	B	289-332	313.3±3.0	11.8±2.2	3.8±0.7
	C	333-347	339.5±2.8	5.5±2.0	1.6±0.6
	D	480-503			
Length to vent	A	567-605	587.3±4.7	12.4±3.3	2.1±0.6
	B	576-652	621.1±4.3	16.8±3.1	2.7±0.5
	C	610-641	631.0±6.1	12.3±4.3	1.9±0.7
	D	617-629			
Head	A	328-353	337.7±3.3	8.6±2.3	2.6±0.7
	B	303-348	324.1±3.2	12.5±2.3	3.9±0.7
	C	339-351	343.3±2.4	4.7±1.7	1.4±0.5
	D	486-517			
Snout	A	68-87	75.7±2.5	6.5±1.7	8.6±2.3
	B	61-77	68.3±1.0	3..8±0.7	5.5±1.0
	C	66-87	74.3±2.7	5.5±1.9	7.3±2.6
	D	75-80			

TABLE 1 (continued)

Feature	Sample	Range	Mean	Standard deviation	Coefficient of variation
Eye	A	86-100	92.7±1.6	4.3±1.2	4.7±1.2
	B	82-100	90.5±1.3	5.0±0.9	5.5±1.0
	C	88-94	91.8±1.4	2.3±0.8	2.4±0.9
	D	100-109			
Interorbital	A	72-102	85.4±3.5	9.3±2.5	10.9±2.9
	B	87-108	99.0±1.6	6.2±1.1	6.3±1.2
	C	90-100	94.3±1.8	3.6±1.3	3.9±1.4
	D	72-86			
1st dorsal spine	A	61-119	90.9±6.9	18.3±4.9	20.2±5.6
	B	75[27]-111	87.1±5.3	20.4±3.7	23.4±4.5
	C	65-91	79.3±5.2	10.4±3.7	13.1±4.6
	D	86-86			
2nd dorsal spine	A	144-206	176.1±7.0	18.5±4.9	10.5±2.8
	B	90-186	150.5±1.6	29.5±5.4	19.6±3.8
	C	139-160	153.0±4.1	8.2±2.9	5.4±1.9
	D	138-156			
3rd dorsal spine	A	144-203	173.1±6.6	17.4±4.6	10.0±2.7
	B	120-180	153.5±4.8	18.7±3.4	12.2±2.2
	C	123-156	144.0±6.3	12.6±4.4	8.7±3.1
	D	131-172			
Spine of second dorsal	A	54-90	69.1±4.2	11.1±3.0	16.0±4.4
	B	50-87	63.8±3.6	10.2±2.5	15.9±3.0
	C	60-68	63.8±1.9	3.8±1.3	5.9±2.1
	D	51-71			
1st dorsal ray	A	116-146	133.4±4.3	9.7±3.1	7.3±2.3
	B	101-151	125.0±3.7	13.7±2.5	11.0±2.0
	C	113-149	129.5±6.4	12.8±4.5	9.9±3.5
	D	105-114			
Longest dorsal ray	A[2]	144-220	178.3±8.5	22.5±6.0	12.6±3.4
	B	150-186	171.7±2.8	10.8±2.0	6.3±1.2
	C	166-197	176.8±6.1	12.3±4.3	6.9±2.5
	D	183-189			
1st anal spine	A	64-90	76.6±4.0	10.6±2.8	13.8±3.7
	B	48-83	64.9±2.7	10.6±1.9	16.4±3.1
	C	54-59	56.3±0.9	1.8±0.6	3.2±1.1
	D	67-71			
2nd anal spine	A[1]	96-168	135.8±8.3	20.4±5.9	15.0±4.4
	B	100-144	116.5±4.0	15.5±2.8	13.3±2.5
	C	96-111	102.0±2.8	5.5±2.0	5.4±1.9
	D	101-109			
3rd anal spine	A	96-141	128.2±5.3	14.1±3.8	11.0±3.0
	B	100-143	117.9±2.7	10.6±1.9	9.0±1.7
	C	99-113	107.0±2.6	5.1±1.8	4.8±1.7
	D	87-103			
Longest anal ray	A	169-216	193.9±6.4	17.0±5.0	8.8±2.4
	B	139-198	169.3±3.5	13.6±2.5	8.0±1.5
	C	171-203	183.5±6.0	11.9±4.2	6.5±2.3
	D	172-200			
Ventral (whole fin)	A	168-206	190.6±5.3	13.9±3.7	7.3±2.0
	B	178-227	198.9±3.7	14.2±2.6	7.2±1.3
	C	181-204	189.8±4.3	8.7±3.1	4.6±1.6
	D	184-205			
Ventral spine	A	97-137	120.4±4.8	12.8±3.4	10.6±2.8
	B	102-140	116.7±3.0	11.7±2.1	10.0±1.8
	C	96-111	105.8±3.1	6.1±2.2	6.0±2.1
	D	97-113			

TABLE 1 (continued)

Feature	Sample	Range	Mean	Standard Deviation	Coefficient of variation
Longest ventral ray	A	156-186	175.7±3.5	9.3±2.5	5.3±1.4
	B	151-210	176.9±4.0	15.3±2.8	8.7±1.6
	C	146-177	161.8±6.2	12.3±4.4	7.6±2.7
	D	166-189			
Pectoral (whole fin)	A[1]	168-213	192.0±5.4	14.4±3.8	7.5±2.0
	B	172-211	196.3±3.0	11.5±2.1	5.9±1.1
	C	189-220	204.8±7.2	14.3±5.1	7.0±2.5
	D	186-207			
Longest pectoral ray	A	159-188	173.0±3.9	9.6±2.8	5.5±1.6
	B	153-189	171.3±2.6	10.2±1.9	5.9±1.1
	C	155-179	167.5±3.1	8.6±3.0	5.1±1.8
	D	160-174			
Depth at opercular border	A	212-314	274.3±13.3	35.2±9.4	12.8±3.5
	B	284-347	307.9±4.1	15.8±2.9	5.1±0.9
	C	297-329	311.3±5.7	11.5±4.0	3.7±1.3
	D	278-286			
Depth at first dorsal origin (maximum)	A	228-334	294.3±13.1	34.8±9.3	11.8±3.2
	B	300-351	329.9±3.6	14.1±2.6	4.3±0.8
	C	338-356	350.0±3.6	7.2±2.5	2.1±0.7
	D	279-309			
Depth at vent	A	217-287	256.3±7.5	19.8±5.3	7.7±2.1
	B	263-322	291.0±3.7	14.3±2.6	4.9±0.9
	C	252-306	284.3±10.7	21.4±7.6	7.5±2.7
	D	259-283			
Depth of caudal peduncle	A	120-170	140.1±5.5	14.6±3.9	10.4±2.8
	B	138-177	156.1±6.9	10.8±2.0	6.9±1.3
	C	152-181	160.5±6.0	11.9±4.2	7.3±2.6
	D	138-154			

Footnote to table 1. [1]6 specimens only; [2]5 specimens only.

TABLE 2

Nannoperca australis Günther, 1861. Value of *t* and significance of *t* for tests of differences of means for certain dimensions and proportions in samples from Australia (7 specimens), Tasmania (15), Flinders Island (4), King Island (2). The six ratios calculated directly from measurements (mm), the seven other features calculated from millesimals of standard length. Single asterisk denotes $P_{0.05}$, double asterisk $P_{0.01}$. H, L indicate the first mentioned locality of the locality pair has the higher, lower, mean value, respectively.

Feature	*t* and significance of *t* for locality pairs: relative magnitude of value for first-named locality					
	Tasmania-Australia	Tamania-King Island	Tasmania-Flinders Island	Australia-King Island	Australia-Flinders Island	King Island-Flinders Island
Length to origin of first dorsal			2.14* H			
Length to termination of first dorsal	2.16* H		3.03**H			
Length to origin of anal	5.37**H		2.20**L	5.60**L	6.79**L	
Length to termination of anal			3.07**L	20.68**L	3.41**L	
Length to origin of ventral			2.38* L		2.88* L	
Head			2.84* L			
Interorbital	7.71**H	3.96**H				2.95* L
Length to origin of anal in length to termination of first dorsal			3.90**L	2.69* H	5.85**H	3.41* H
Head in standard length	3.71* H			2.55* L		
Interorbital in eye	4.67**L	8.91**L	2.18* L			9.78**H
Eye in head		13.76**H	2.45* L	2.64* H	4.93**L	4.77**L
Snout in eye			10.26**H			2.42* H
Maximum depth in standard length	3.25**L	4.26**L	3.14**H			4.77**H

Family KYPHOSIDAE

The Check-List includes 6 species: *(a) Kyphosus* Lacépède, 1802, (1) *K. indicus* Cuvier, 1831, (2) *K. cinarescens* (Forskal), 1775, (3) *K. sydneyanus* (Günther), 1866, (4) *K. gibsoni* Ogilby, 1912; *(b) Dioidyxodon* Thominot, 1881, (5) *D. australis* Thominot, 1881; *(c) Tilodon* Thominot, 1881, (b) *T. australis* Thominot, 1881. Entries (5), (6) formally record material from 'Australie' (Verreaux; descriptions *ex* Guichenot MS): neither has since been recognized from our waters, and both are now dropped by Whitley (1964) from the Australian list. There are, however, now to be added: (7) *K. vaigiensis* (Quoy & Gaimard), 1825, Queensland and widely *extralimital,* (8) *K. cornelii* (Whitley), 1944, Western Australia (Pelsart Island, Houtmans Abrolhos); (9) *K. diemenensis sp. nov.,* the first kyphosid recorded from Tasmania.

In the latest Australian list (Whitley, 1964), (1), (3), (7), (8) are referred to the genus *Segutilum* Whitley, 1931 [(1) as *S. klunzingeri* Whitley, 1931]; (2) to *Opisthistius squamosus* (Alleyne & Macleay), 1877; (4) to *Leptokyphosus* Whitley [originally established (1931: 370) as a subgenus of *Segutilum*].

Hitherto no member of the family has been reported from Tasmania, though *K. sydneyanus* is known from South Australia and New Zealand. Species (1) [as Cuvier's species, not as Whitley's, the latter being Western Australian], (2), 7 range extralimitally.

A provisional key [the observation by Schultz (1953: 565) 'The kyphosids of the Indo-Pacific are in need of further careful study' has current relevance in terms of the Australian scene] to species (1)-(4) (7)-(9) is here offered. The species appearing in the Check-List as *K. indicus* Cuvier presents special difficulty. Cuvier's account, ex Kuhl & Van Hassett MS, cites no locality (the Check-List suggests 'probably Java'); while the specimen described under this name by Klunzinger (1879: 357, pl. vii) came from King George's Sound, Western Australia. In a survey of the family McCulloch (1920: 56) headed his account of the Australian fish *'Kyphosus indicus* (Cuv. and Val.?), Klunzinger', and again expresses his uncertainty in his synonymy with '(perhaps not *P. indicus,* Cuv. and Val.)' [the section of vol. vii of *Histoire Naturelle des Poissons* in which the species is treated of is by Cuvier]. He remarks, 'The identity of the specimen from King George's Sound, characterised and figured by Klunzinger remains uncertain. He counted about 66 scales on the lateral line, but this figure shows only 55 pierced scales; it also shows about 54 rows between the supraclavicle margin and the hypural joint. The illustration was prepared by Eduard Konopicky, however, whose work is notable for its accuracy, which suggests that Klunzinger may have counted the scales incorrectly. The specimen is possibly a rather slender example of *K. sydneyanus* Günther, which species has been recorded from Western Australian waters'. Commenting on this last sentence, Whitley (1931: 320) remarked 'it is unlikely that this restricted New South Wales species recurs in Western Australia', and renamed Klunzinger's species *Segutilum klunzingeri,* with, as type, the specimen figured on Klunzinger's plate by Konopicky. The position regarding the lateral line count remains unresolved; the best that can here be done is to adopt the expedient forced on McCulloch in the construction of his key, namely, to work on the basis of Klunzinger's text and accept, provisionally, his specification of 66 lateral line scales. With regard to (2), Whitley observes 'the species from northern Australia called *Kyphosus cinarescens* by

KEY TO AUSTRALIAN KYPHOSIDAE

1	Anal rays 14. Dorsal rays 15-16	*K. cornelii*
	Anal rays 11-13. Dorsal rays 12-15	2
2	Base of soft dorsal $<$ base of spinous dorsal	3
	Base of soft dorsal $\geq$ base of spinous dorsal	6
3	Anterior dorsal rays $>$ longest spine	*K. cinarescens*
	Anterior dorsal rays $\leq$ longest spine	4
4	L. lat. $>$ 60. L. lat. 66 (Klunzinger)	*K. klunzingeri*
	L. lat. $<$ 60	5
5	Pierced scales of l. lat. $\doteq$ 55 ($\doteq$ 5 past hypural joint). Scales between posterior margin of supraclavicle and hypural joint $\doteq$ 52. Second dorsal base shorter relative to first dorsal base, $\doteq$ 1.8 in it measured between parallels, or $\doteq$ 1.5 measured point to point. Ventral originating below, or barely behind, pectoral base. Head $\doteq$ 3.6 in standard length. Eye $\doteq$ 3.9 in head, $\doteq$ 1.7 in interorbital	*K. sydneyanus*
	Pierced scales of l. lat. $\doteq$ 45 ($\doteq$ 2-6 past hypural joint). Scales between posterior margin of supraclavicle and hypural joint $\doteq$ 43. Second dorsal base longer relative to first dorsal base, $\doteq$ 1.4 in it measured between parallels, or $\doteq$ 1.2 measured point to point. Ventral originating behind pectoral base by about longitudinal extension of oblique pectoral base. Head $\doteq$ 4.0 in standard length. Eye $\doteq$ 4.6 in head, $\doteq$ 2.4 in interorbital	*K. diemenensis*
6	Dorsal rays 14-15. Caudal shallowly and evenly excavate. Head $\doteq$ 3.5-3.7 in standard length. Eye $\doteq$ 3.0-3.6 in head	*K. vaigiensis*
	Dorsal rays 13. Caudal moderately forked. Head $\doteq$ 4.0 in standard length. Eye $\doteq$ 4.3 in head	*K. gibsoni*

Australian authors would be better known as *Opisthistius squamosus* (Alleyne & Macleay)'. Alleyne & Macleay's *Pachymetopon squamosum*, and their *Scorpis vinosa*, treated (it would seem correctly) in the Check-List as synonymous with it, collected by the *Chevert* in Hall Sound, New Guinea and at Darney Island, respectively, are figured (1877, pl. ix, figs 1, 2) in the report on the expedition's ichthyology. As Forskal's species has a wide extralimital range, including Red Sea (type locality), Japan, East Indies, the suggestion for the adoption of Alleyne & Macleay's name is no doubt based on a probability of an Australian and ad-Australian species being distinct from one ranging well into the northern hemisphere. Alleyne & Macleay's figures are poor: in preparing the key reference has been made to the standard figure of *K. cinarescens* in Bleeker (1877, pl. ccclxiv, fig. 4), reproduced in, *e.g.*, Munro (1967).

Kyphosus diemenensis sp. nov.

(Fig. 1).

Description, D. xi, 12. A. iii, 11. P. 19/18. V. 1, 5. C. 18 (1 + 16 + 1). Pierced scales of lateral line 45, of which 2 are beyond hypural joint, followed by 4 scales unpierced, but bearing shortish tubules. About 54 rows of scales above lateral line between its origin and hypural joint, the anterior ones irregular; 43 rows between posterior margin of supraclavicle and hypural joint. Scales between origin of dorsal fin and lateral line 10; about 21 more to ventral surface. Predorsal scales, from occiput, about 58.

Depth before ventrals 2.38, at vent 2.22, maximum depth 2.18, depth of caudal peduncle 8.03, in *Ls.* Breadth at pectoral base 2.01 in depth there. Head 3.96 in *Ls.* Eye shorter than (1.24 in) snout, 2.38 in interorbital, 4.59 in head. Snout 3.71, interorbital 1.98 in head. Depth of caudal peduncle 1.13 in its length, 2.05 in head. Sixth dorsal spine 2.20, longest (5th) spine 2.09, 2nd dorsal 3.90, longest (8th) dorsal ray 2.23, longest (1st) anal ray 2.21, longest (5th) pectoral ray 1.60, pectoral (whole fin) 1.36, in head.

Body broadly elliptical, compressed, dorsal and ventral profiles almost evenly, and almost equally, arched. Head obtuse; its depth at front of eyes 1.28, at back of eyes 0.98, at opercular margin 0.68, in its length; snout very convex to level of posterior nostril; profile then barely convex about to level of middle of pupil; thereafter, with marked increase in general sense of slope, in gently convex, almost even, arc to origin of dorsal. Eye wholly in anterior half of head; its highest point below dorsal profile by about two-thirds eye-diameter; interorbital convex both transversely (markedly) and anteroposteriorly. Preorbital, dorsum of snout to level of anterior nostril, chin to same level, lips, naked; these regions covered with minute vermiculate elevations, and, except for lips, sprinkled with small pores. Preorbital striated; about a score of points along lower half of border. Preopercular margin corrugated and serrated; about a score of crenulations along hinder four-fifths of inferior border; ridges becoming larger and farther apart along lower two-thirds of exposed vertical border, rest of border without noticeable ridges. Nostrils approximate, interval between them less than distance of posterior nostril from eye; the anterior a subcircular opening ringed with low membranous tube, its distance from its fellow subequal to its distance from middle of eye, or 0.56 interorbital; the posterior elliptical (major axis slightly oblique to anteroposterior axis of fish), fringed with skinny lips, a groove running beneath it and extending behind opening by about length of latter. Maxillary with small subtriangular patch of scales at its posterosuperior border, which just reaches level of anterior orbital margin; jaws equal; lips broad, with the characteristic generic form; a line from upper border of upper jaw to base of last dorsal ray passes across middle of eye. Teeth in jaws in a single row, about 25 in upper, about 30 in lower; variable in form, the anterior ones higher, subconical, height subequal to base, with or without indications of 1 or 2 secondary cusps, the hinder ones lower, compressed, tending to present, in frontal aspect, a more or less rectangular outline, the free margin usually with 3, or fewer, low cusps. Minute teeth on vomer in a transversely elliptical patch; on each pterygoid in a longitudinal ellipsoidal patch, its length subequal to diameter of eye, rather more than twice its own length; on the anterior part of each palatine in a very small patch. Tongue damaged, its tip missing; intact portion edentulous. Gillrakers on anterior 6+14; those on lower limb long, slender, subcylindrical, pointed, length of longest 7 mm, about half length of gill filament, subequal to space occupied by bases of 5 rakers, last (lowest) shorter than rest, about half length of penultimate; those on upper limb much shorter, stouter, with blunt, or even slightly clubbed ends, except the lowest 2, which are similar to, but somewhat more compressed than rakers of lower limb. Body covered with ctenoid scales, which extend on to most of head (see above), also over greater part of all paired fins, forming conspicuous sheaths at the bases of the anal and the soft dorsal, but occurring only in a narrow proximal strip on spinous portion of dorsal. Whole of pectoral base and more than half fin covered with small scales. Lateral line following more or less closely curve of back, its direct distances from bases of first dorsal spine and last dorsal ray equal; proceeding along middle of caudal peduncle: each pierced scale with, towards its posterior border, a low chimney of gelatinous appearance, conspicuously white against brownish olivaceous body and black rim of scale; the last 4 lateral line scales not thus pierced, but bearing a shortish longitudinal tubule. Posttemporal bone with about a dozen serrations.

Dorsal commencing behind insertion of ventral by about half snout-length; margin evenly arched; longest (5th) spine 2.26, 1.87, 1.64, 1.07 length of 1st, 2nd, 3rd, 8th (longest) ray. With both measured between parallels, soft dorsal base 0.56 spinous base; measured directly, with dividers, 0.72. Soft dorsal margin very slightly convex; rays increasing to 8th, which is 2.12 1st; thereafter decreasing to penultimate, 12th being 1.08 11th, which is 2.32 in head. Anal originating in advance of soft dorsal, its 1st ray about below 1st ray of that fin; terminating briefly in advance of dorsal, the fin bases equal; 3rd spine 1.03 2nd, 1.67 1st, which is 6.50 in head; 1st ray longest, probably decreasing to 5th (3rd, 4th imperfect), then increasing to 8th, decreasing to last, which is 1.41 in 1st, 3.11 in head. Pectoral short, broad, rounded; to below 4th dorsal spine, its total length equal to head without snout; first 2 rays unbranched; longest (5th) ray 1.60

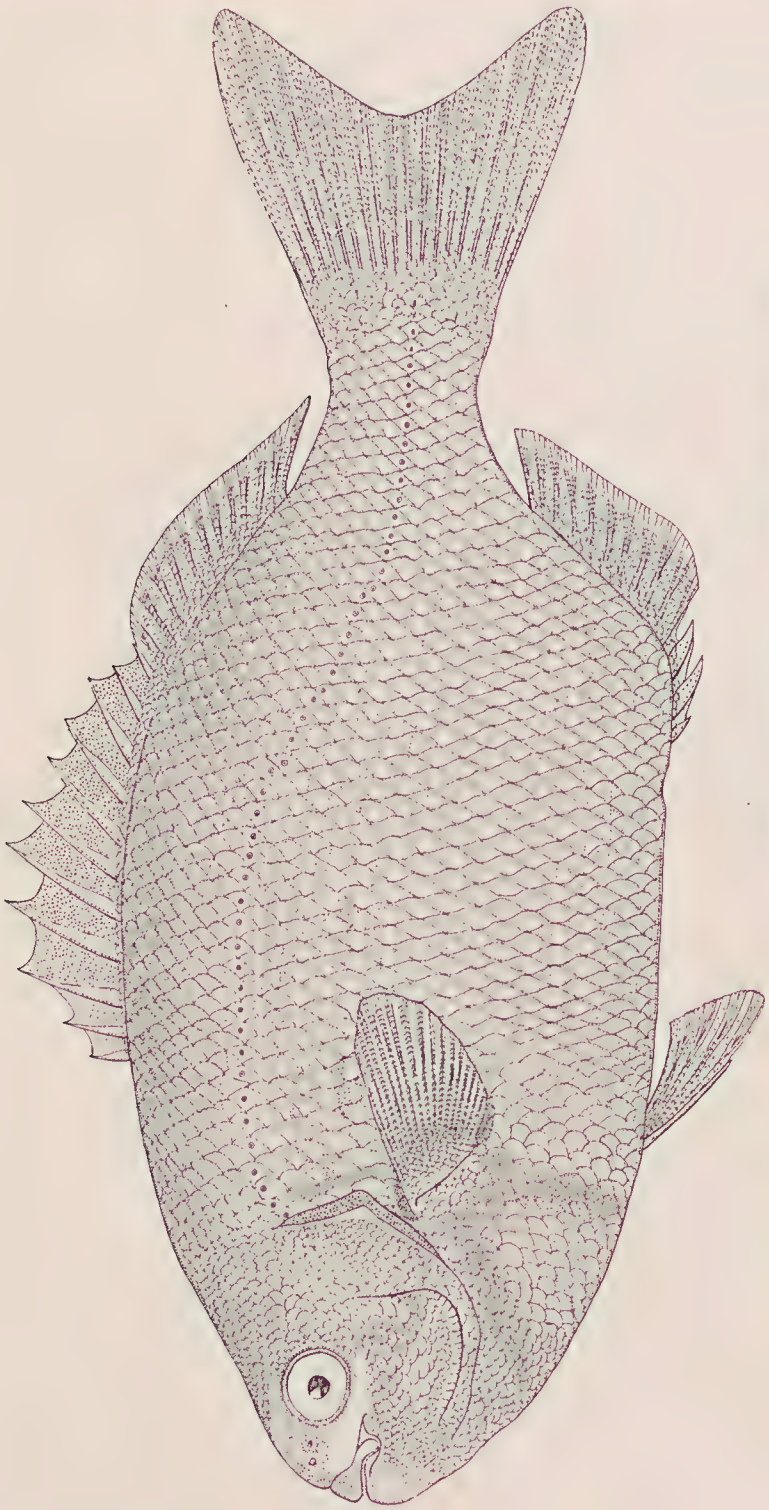

Fig. 1.—*Kyphosus diemenensis sp. nov.* Holotype, total length 387 mm, standard length 307 mm; north coast of Tasmania; Queen Victoria Museum Reg. No. 1967.5.26 : x ½.

in head, a trifle longer than middle ventral ray. Ventral originating behind pectoral base by a distance subequal to anteroposterior extension of the oblique pectoral base; or by 0.9 eye; extending 0.74 of distance to middle of vent; longest (2nd) ray 1.46 in head, 1.66 spine. Caudal subequal to head; deeply emarginate, the outer rays extending behind median rays by about one-third of fin; lobes bluntly rounded.

The above description, while somewhat more detailed than the account given by McCulloch (1920: 56) of K. *sydneyanus* Günther, is drawn up to be directly comparable with it. The statement in that account (p. 57) that the scales form sheaths at the bases of 'the dorsal and anal spines' is doubtless to be read with 'rays' substituted for 'spines'. 'Anal a little farther back than the soft dorsal' — this apparently refers to the rayed portion of the anal; the figure (pl. XII, fig. 2) showing 1st anal spine well in advance of 1st dorsal ray.

Lateral surface of body brownish olivaceous, lightening ventrally, and below about midlateral line showing an increasingly silvery tinge. Almost all scales with a lighter area; above lateral line mostly reduced to a spot, or short subvertical bar, of greyish (on a few scales just above lateral line near head, warm brownish) at front of scale, posteriorly most scales lighter, modal pattern being light greyish marked with pale chestnut, the latter sometimes constituting anything from a single diffuse patch to a central anteroposterior stripe, sometimes occurring in two diffuse patches, separated, with varying degrees of distinctness, by a median area of greyish or whitish; below lateral line a conspicuous deep yellow, or castaneous, mark on all scales, except most of those of caudal peduncle, which are mainly greyish or silvery grey, the marking varying from a diffuse patch, sometimes extending over most, or whole, of front part of scale, but always being most prominent round anteroposterior axis of scale, where its greater intensity may sometimes result in its presenting more or less the appearance of a longitudinal stripe: most scales, both above and below lateral line, bearing, in addition to markings described above, a darker, commonly brownish, area on hind margin; and being largely or wholly outlined by dark membranous fringes. The presence of the yellowish spots results in the formation of a series of lateral stripes, conspicuous over most of flank; least development on caudal peduncle, above lateral line, and near ventral profile, between which latter two limits about a dozen stripes are immediately obvious, with several others more or less clearly traceable. A small black subrectangular marking, its height a little less than half its length, the latter half an eye-diameter, is apparent at lower angle of pectoral base: when pectoral is lifted away from trunk, the marking is seen to continue upwards, as a bar, several millimetres across, to level of upper pectoral rays of fin when adpressed, *i.e.*, for a distance of about one-third head-length, fringing for the whole of its exposed vertical extent the hind border of a bone (coracoid?) of the pectoral girdle. An obscure darkish bar immediately posterior to the free border of the supraclavicle, lying a little behind, and subparallel with, vertical limb of operculum. Lateral line a series of subcircular openings, conspicuously rimmed with white. Dorsal surface tending to be darker than upper lateral, anteriorly approaching black, the lighter scale markings here obsolete. Ventral surface ranging from dark flesh to pale yellow, this ground color extending up briefly on to flank.

Lateral surface of head chiefly dark olivaceous, becoming lighter on lower cheek and chin, which are mostly pale brownish. Preorbital with a wide border of light brown and dark fawn; below and behind this a dark longitudinal pennon, running back beneath eye almost to preorbital margin, broadening as it goes, and finally curving upward to occupy most of area between orbit and preopercular border. A narrow circumorbital ring of dark brown. Membrane bordering vertical limb of operculum presenting a black and blackish bar, with somewhat sinuous hind margin; its anteroposterior extent from about one-fifth to about one-third an eye-diameter, its vertical subequal to length of postorbital head. Lower lip dusky, upper dark. General dorsal surface of head blackish; ventral surface more or less concolorous with lower lateral surface.

First dorsal olive black. Sheath of second dorsal, extending over more than two-thirds length of rays, very dark brown; free tips of rays a trifle lighter. Small scales sheathing base of anal light brown, faintly purplish, darkening distally; exposed rays dark brown, extreme tips ashen. External surface of pectoral base pale brownish; fin pale brownish and dusky, proximally, ashen distally, the lighter region accounting for about one-sixth of length of upper rays, broadening below to cover about four-fifths of lowest rays: inner surface of fin proximally black and blackish up to the inner limit of distal ashen area of outer surface. Ventral spine whitish; outer 4 rays whitish proximally, darkening distally, most extensively so in 2nd and 3rd; inner ray faintly dusky; membrane dark, between outer rays black. Caudal mainly very dark grey, with some brownish; the outer 2-3 rays, both above and below, olivaceous basally, the colour in upper lobe continuing to tip, the lower lobe darkening distally; distal one-third or so of the inner rays lighter than their bases; tips of all rays, except those of the fin lobes, briefly ashen.

Dimensions as TLs. The following dimensions are expressed as millesimals of the standard length, 307 mm. Vertical fins are treated as originating and terminating at relevant spine or ray, terminal membranes, if any (here, only between spinous and soft dorsals) being disregarded.

Length to origin, termination of spinous dorsal 375, 632; of second dorsal 656, 844; of anal 629, 821. Length to, length of pectoral 235, 187; to, of ventral 300, 184. Length to middle of vent 588. Head 254; snout 68; eye 55; interorbital 135; internarial (anterior nostrils) 75. Depth (in parentheses, width) at: front of eyes 199 (133), back of eyes 261 (163), pectoral origin 365 (174), opercular margin 371 (176), ventral origin 420 (171), vent 450 (156); maximum 459 (179); caudal peduncle 124 (47).

Length of ventral spine 105; of rays 1-5, 167, 174, 150, 124, 101. Lengths of dorsal spines I-XI, 33, — 101, 118, 120, 116, 106, 102, 96, 67, 46. Lengths of dorsal rays 1-12, 54, 65, 79, 91, 95, 101, 101, 114, 104, 101, 101, 109. Lengths of anal spines I-III, 39, 64, 65; of rays 1-11 115, 107,

—, —, 86, 95, 98, 101, 98, 94, 82. Lengths of pectoral rays 1-15, 68, 121, 133, 154, 159, 151, 110, 104, 92, 81, 71, 65, 55, 97, 37.

Material. Described and figured (fig. 1) from the unique holotype, 307 mm in standard length, 387 in total length, collected on the north east of Tasmania in January 1967 (Q.V.M. Reg. No. 10.10.67): gutted.

The specific trivial name, *diemenensis,* derives from the locality of the type (Van Diemen's Land, the original name of Tasmania).

Affinities. Apart from *K. cornelii* (Whitley), 1944 (not hitherto appearing in a family key) in which the relative lengths of soft and spinous dorsals cannot be satisfactorily determined from the photograph of the type (1944, fig. 3) (? subequal) — but which appears, in any case, to stand clear of all other Australian species in having 14 (*cf.* 11-13) anal rays, 15-16 (*cf.* 11-15) dorsal rays — the primary separation in current keys (McCulloch, 1920; Marshall, 1964) turns on whether base of soft dorsal is less than, or greater than (or subequal to) base of spinous dorsal.

The existence of a longer spinous base in the present species at once separates it from *K. vaigiensis* (Quoy & Gaimard), 1875 and from *K. gibsoni* Ogilby, 1912. Among the remaining species, *K. cinarescens* (Forskal), 1775 is ruled out by its having anterior dorsal rays (much) longer than longest spine. There thus remain for consideration *K. klunzingeri* Whitley, 1931, *K. sydneyanus* (Günther), 1886, and the present species. The problem presented by the imperfectly known *K. klunzingeri* has been considered above: if Klunzinger's lateral line specification of 66 is to be relied on, this feature differentiates it clearly from the present species with a count of 45.

The nearest ally of *K. diemenensis* would appear to be *K. sydneyanus.* From that species it is distinguished by the following characteristics (specifications of Günther's species in parentheses): *(i)* lateral line with 45 (about 55) pierced scales; *(ii)* scales between posterior margin of suprascapular and hypural joint about 43 (about 52); *(iii)* ventral orginating further back, behind pectoral base by about longitudinal extension of pectoral base, or by more than an eye-diameter (below, or barely behind, pectoral base), in this feature resembling *K. cinarescens, K. vaigiensis, K. gibsoni; (iv)* second dorsal base longer relative to first dorsal base, 1.4 (about 1.8) in it, measured between parallels, or 1.2 (about 1.5) measured with dividers; *(v)* head smaller 4.0 (3.6) in standard length; *(vi)* eye smaller, 4.6 (about 3.9) in head; *(vii)* perhaps rather wider interobital, 1.92 (2.1) in head. McCulloch's figure of *K. sydneyanus* (pl. XII, fig. 2) would appear to depict a fish with a greater difference in height between the dorsals than our specimen, the longest spine there being perhaps 1.25 the longest ray, as against 1.02 in our example. McCulloch apparently found in his *K. sydneyanus,* a young specimen, 245 mm long (the stuffed type is 30 inches), 6th dorsal spine the longest; in ours it is 5th, which is 1.05 6th. There may well be some differences in coloration in these two species.

In addition to the major differences mentioned above, *K. diemenensis* differs from *K. vaigiensis* in having fewer pierced scales (45; *cf.* 56-58); fewer dorsal rays (12; *cf.* 14-15); fewer anal rays (11; *cf.* 12-13), fewer gillrakers (20 *cf.* 30); from K. gibsoni in having fewer pierced scales (45; *cf.* 59), one fewer ray each in dorsal and anal; greater depth before ventrals (2.38 in *Ls; cf.* 2.6); from *K. cinarescens* in having fewer pierced scales (45; *cf.* 48-56), fewer gillrakers (20: cf. 26-30): from *K. cornelii* in having fewer pierced scales (45; *cf.* 50+6), deeper body (greatest depth 2.18 in *Ls; cf.* 3.0).

Family XIPHIIDAE

Genus **XIPHIAS** Linné, 1758

Xiphias gladius Linné, 1758

Xiphias gladius Linné, 1758, *Syst. Nat.,* ed. 10:248. Type locality, in Oceano Europae.

Tasmanian examples. This species does not appear in any local faunal list, but is recorded for Tasmania (and all other Australian States) in the Handbook (Munro, 1958: 115, fig. 766). The measurements reported below — taken with a steel tape marked in inches, and here converted to millimetres (largest dimensions should be acceptable to nearest centimetre) — were made on 17 April 1969 on a specimen caught by Mr T. Pyke of Bicheno, Glamorgan, and placed on a display in a Launceston sports store. The weight was stated to be 230 lb. A photograph (unfortunately not very suitable for reproduction here) appeared in the Launceson *Examiner* of this date. Earlier, that newspaper had reported, on 13 March, that Mr Keith Jessup of Launceston had hooked, but not caught, a large broadbill swordfish off Schouten Island, Glamorgan. It quoted Mr Jessup as stating he had the fish hooked for more than ten minutes. 'In that time he tail-walked several times and I could see he was about 12 ft long and would weigh more than 200 lb.' Munro observes 'not yet taken in Australian waters by game anglers', and the hooking of an example by Mr Jessup may be the first time this has been achieved.

Dimensions. Total length 3102; length to end of middle caudal rays 2686; standard length 2638. Tip of upper jaw to middle of anterior border of forwardly concave rictal membrane 1036: top of upper jaw had apparently suffered damage during life, with bilaterally asymmetrical healing, the portion presumably missing probably not exceeding a few centimetres in length. Length of lower jaw (tip intact) to rictal membrane as before 198. Head 1265; snout 933; eye 68, with lid 87; interorbital 62. Length to origin, termination of first dorsal 1025, 1415; of second dorsal 2210, 2242; of first anal 1978, 2204; of second anal 2412, 2437. Length to middle of vent 1938. Length of pectoral 403. Oblique length of upper caudal lobe 551, of lower, 542; spread of caudal 777. Length of caudal keel 218. Width of upper jaw at angle of gape 160; depth there 161. Depth at origin of first dorsal 372, at vent 306; maximum depth 403; depth of caudal peduncle 84.

The small second dorsal and small second anal are more or less L-shaped; the shorter limb erect; the longer limb horizontal (dorsal) or subparallel with body profile (anal).

Comparison with Handbook Specifications. Comparison with the values for 5 ratios given by Munro (1958: 115) yields the following results (our data in parentheses): upper jaw 3.8 (4.71) lower jaw; depth 5.2 (6.55) in *Ls;* head with spear 1.8 (2.09) in *Ls;* elevated lobe of first dorsal 1.1 (1.45) in body depth; pectoral 1.3 (1.00) in body depth. Inspection of the figure in Munro and the press photograph of Mr Pyke's specimen

shows good overall agreement (including eye-mouth relations: see remarks on taxonomy, below), the most notable differences being the occurrence in the latter of a longer first anal, and of a more caudad location of second anal relative to second dorsal.

Taxonomic status. Xiphias gladius Linné, 1758 [variant spellings include *Xiphius, Ziphias, Ziphius; gladias*] is generally regarded as being cosmopolitan; thus Briggs in his paper on fishes of worldwide distribution observes (1960: 177) 'Herre (1953: 256) [Herre, A W. 1953. Check list of Philippine fishes. *U.S. Fish and Wildl. Serv. Res. Rept,* No. 20: 1-97] and almost all previous authors list this species for all tropical and temperate seas'.

The broadbill swordfish found in Australian and New Zealand seas has in general been regarded as being Linné's species — *cf.,* for example, Hutton (1904), Waite (1921), McCulloch (1929), Munro (1958), Scott (1962), Parrott (1959). However, Phillipps, after having published in 1926, under the name of *Xiphias gladius,* a drawing by F. E. Clarke of a swordfish washed ashore on Hakitaka beach, and having observed of this figure (pl. 91) 'It appears to agree very well in all essential features with Cuvier's figure of the species, reproduced by Jordan and Evermann (1903, *loc. cit.)*' [*Bull. U.S. Fish. Com.,* 23: 168, fig. 61], in a subsequent paper (1932) named the same specimen as type of a new species, *X. estara.*

Phillipps states (p. 138) 'The main point of difference between the New Zealand and Atlantic swordfishes is to be found in the position of the eye, which in our species is relatively larger and placed farther forward than in the *gladius.* It will be seen that the angle of the mouth is far behind the eye and the tip of the lower jaw a little in front of the eye in the New Zealand fish, while the reverse is the case in the Atlantic species'. In his work on the fishes of South Australia Scott (1962) reproduces the figure in Phillipps' 1962 paper, labelling it *Xiphias gladius,* a course adopted also by Parrott (1959: 179). While accepting Phillipps' name of *X. estara,* Whitley (1962: 187, and unnumbered fig. on that page) presents a figure, 'Modified after Phillipps', in which the postocular extension of the mouth appears to be less than in the original. Apart from Clarke's drawing or modifications of it, figures of the broadbill swordfish at hand, whether purporting to depict the fish as it occurs in the northern or in the southern hemisphere, show the angle of the mouth located behind the eye [if behind it at all — a crude figure in an 1859 English edition of *Régne Animal* (marked *Xiphias clodius; sic*) has mouth ending in advance of middle of eye] by a distance less than, at most subequal to, the distance between level of front of eye and tip of lower jaw — thus suggesting the diagnosis of *X. estara* is not applicable to the common broadbill sword fish of the southern hemisphere. Linnés species apparently being, as it is generally held to be, a cosmopolitan one.

In the present example the diameter of the eye is 60 (with lid 87); the mandible extends 95 in advance of eye, the mouth 43 behind eye.

Some points of comparison between Phillipps' account of *X. estara* and the present fish, additional to those concerning relationships of eye, mouth-angle, mandible-tip already discussed, may be noted (our specifications in parentheses). Head [*i.e.,* from tip of lower jaw] approximately 5 (4.21) in length from tip of mandible to tip of caudal. Depth at opercular edge nearly 6 (4.84; depth at dorsal origin) in length as before. Tip of spear to eye approximately equal to distance between origin of pectoral and origin (first one-third of base) of first anal. Mandible ½ (0.46) head. Eye 6.80 (7.1) in head. First dorsal rising to a height almost equal to (vertically 0.65, obliquely 1.16) length of head. Length of pectoral approximately equal to (1.08) depth at opercular margin (at dorsal origin). First anal 'sometimes originates' at a point a little (decidedly) nearer to operculum than to tip of caudal.

Family LEPTOSCOPIDAE

The Check-List (McCulloch, 1929: 334) records two species: *(a)* genus *Crapatalus* Günther, 1861, *C. arenarius,* McCulloch, 1915 (Queensland, New South Wales, South Australia); *(b)* genus *Leptoscopus* Gill, 1860, *L. macropygus* (Richardson), 1846 (New South Wales). The second species occurs also in New Zealand — a neozealandic subspecies, *L. m. Luttoni* Haast, 1873, is recognized by Whitley (1968: 67); in New Zealand Günther's genus is represented by *C. novaezelandiae* Günther, 1861 and *C. angusticeps* (Hutton), 1874. No member of the family has hitherto been reported from Tasmania.

Genus **CRAPATALUS** Günther, 1861

Crapatalus arenarius McCulloch, 1915

Crapatalus arenarius McCulloch, 1915, *Proc. Linn. Soc. N.S.W.,* xl, 2: 269, pl. xxxvii, fig. 1. Type locality, Narrabeen, near Sydney, N.S.W.

Leptoscopus macropygus Ogilby, 1912, *Mem. Qld Mus.,* 1: 57 *(non Uranoscopus macropygus* Richardson, 1846).

Tasmanian record. This species — to the distribution of which is given in the Check-List (see above) Western Australia is added in Scott (1962) — can now be added to the Tasmanian list, an example, *Ls* 75.9, *Lt* 85.6 having been secured by Mrs J. M. Wright at Green's Beach, Devon, on 20 January 1970 (Queen Victoria Museum Reg. No. 1970.5.24). The fish, which appeared sluggish, was caught by hand in 2-3 feet of water as Mrs Wright was getting into a boat. A second example, seen at the time by some children, was not captured.

Counts, proportions as TLs. D. 34. A. 37. P. 21/21. V. i, 5. C. 10. L. lat. 47; l. tr. obliquely backward at dorsal origin 5/1/8, at middle of tail 5/1/5.

Length to origin, termination of dorsal 352, 964, of anal 291, 964; length to ventral origin 138, to pectoral origin 191. Head 224, snout 40, eye without lid 32 with lid 40, interorbital 38, internarial (anterior nostrils) 51. Length of ventral fin 125, of pectoral 240; longest (4th) ventral ray 105, ventral spine 40, longest (8th) pectoral ray 211, longest (about 7th) dorsal ray 69, longest (about 7th) anal ray 66. Depth (in parentheses, width) at back of eye 99 (132), at operculum 124 (137), greatest depth, occurring at dorsal origin, 132 (greatest width, occurring at middle of postorbital head, 182). Total length 1128.

Comparison with McCulloch's description. McCulloch (1915: 269) gives certain proportions for his figured specimen, 85 mm long, as follows (our values in parentheses). Head in *Ls* 3.5 (4.47); depth at vent in *Ls* 7.4 (7.91), in head 2.1 (1.77). Eye in head 7.0 (without lid 7.25, with lid 5.67). Depth of caudal peduncle in head 5.2 (4.86) Seventh dorsal ray in head 3.3 (3.27), seventh

anal ray 3.3 (3.40). Longest pectoral ray in head 1.1 (1.06), longest ventral ray 2.3 (2.13), caudal fin 1.9 (1.75).

In general our specimen is in good agreement with his account. However, several points of difference are to be noted. *(i)* 'Head entirely naked. Body covered with large cycloid scales extending to above the operculum on the back, and to behind the pectoral and ventral fins on the lower surface.' Scales on the dorsal surface certainly extend forward of the front of the operculum, and appear to continue, though in a somewhat more deeply embedded condition, over the whole interorbital region to, or almost to, the upper lip. There are also indications of the probable existence of a band of scales across the upper part of the operculum and the preoperculum to the eye, then continuing forward as a single row beneath the orbit. *(ii)* 'Lateral line almost straight from the suprascapular along the middle of the body to the base of the caudal'. While the overall sense of the line is rectilinear, the anterior portion, back to the level of the posterior one-fifth of the adpressed pectoral, is somewhat sigmoid, and runs steeply upward and forward. *(iii)* In the described specimen the maxillary reaches just past the eye, but in the two other examples it 'does not reach quite so far': in the Tasmanian fish it extends to below the middle of the eye. *(iv)* Between the tips of the two small spines on the breast (which are less developed than seems to be suggested by the figure) there occurs a small orifice that while possibly a mutilation presents no obvious indication of being such.

Additions to original account. Labial cirri olivaceous, slender, distally acute; set for their whole, or almost their whole, length in a whitish gelatinous matrix; about 34 in the upper lip, about 48 in the lower. Anterior nostril a subcylindrical process of gelatinous appearance; rounded, and somewhat expanded, distally; with small circular terminal opening; encircled basally by a low thin gelatinous ring; situated about equidistant from anterior border of preorbital and orbital rim; internarial distance a trifle more than half as great again as interorbital. Posterior nostril smaller than, but apparently similar to, anterior; located just externad of it, hard against orbit. About 15 cirri, similar in shape, and size to those of lips, and, like them, largely set in gelatinous material, fringing upper angle of operculum, about two-thirds of them on superior border; so disposed as to lie convex outwardly. Tubules of lateral line extending across all, or almost all, exposed length of scale; each a slender tube. bifurcating briefly at posterior end.

Coloration. Body: general colour olivaceous, lightening, without abrupt change, to pale greyish or whitish ventrally; delicately mottled with greyish over all the back, half down the flank anteriorly, down to ventral profile in last one-third of tail; most scales bordering either side of anal base with a small sharply defined subcentral black spot; at 2 scale-rows higher a similar line of dots, extending forward to level of pectoral base, but becoming obsolescent at about the middle of the length; lateral line tubules whitish. Head: in general more or less concolorous with body, but somewhat darker on dorsal surface; a dark bluish blotch on dorsum, a little closer to eyes than to end of head; a light immaculate area on lower half of preoperculum flanked, behind and above at posterior preopercular border, by an obscurely delimited dark bar; labial cirri dusky, in whitish matrix; opercular cirri colourless, in hyaline or faintly opalescent matrix; anterior nostril white, posterior largely hyaline. Fins: dorsal rays greyish, punctulated on their anterior surface with pale brown, the peppering varying in intensity along the length of the ray, giving the effect, especially in anterior part of fin, of a system of faint cross bars, membrane whitish; anal rays and membrane pale, both lacking punctulations; pectoral pale, with faint yellowish tinge distally, a few small scattered melanophores at base; ventral colourless; caudal rays mostly pale yellowish, several whitish, all rendered somewhat dusky basally by a sparse sprinkling of chromatophores. The coloration would seem in all respects admirably adapted to a sand-dwelling habit such as that reported for this fish by McCulloch.

Reduced trunk length. Crapatolus arenarius is one of the few fishes with the anal fin originating far forward, anterior to dorsal origin; the unusually cephalad location of the vent reducing the length of the formal trunk to a small fraction of the length of the fish. In the specimen, head, trunk, tail account for 22, 6, 71 per cent, respectively, of the standard length.

Family OPHIDIIDAE

All three Australian members of the family — *(a) Genypterus Philippi,* 1857 (1) *G. blacodes* (Bloch & Schneider), 1801, (2) *G. microstomus* Regan, 1903; *(b) Dannevigia* Whitley, 1941, (3) *D. tusca* Whitley, 1941— occur in Tasmania: however, though (2) has this State— as one of its type localities (Tasmania, Dunedin, Stewart Island) it has missed inclusion in any published Tasmanian list.

KEY TO TASMANIAN OPHIDIIDAE

1	Dorsal with < 125 rays (about 103). Anal with < 100 rays (about 8). Lateral line < 150 (about 100)	*Dannevigia tusca*
	Dorsal with > 125 rays (about 150-160). Anal with > 100 rays (about 123-126). Lateral line > 150 (about 290-300)	2.
2	Maxillary extending well beyond orbit. Eye much smaller than snout; 6.9-9.6 in head. Body pinkish, purplish, or whitish; with irregular dark brown or blackish mottlings of different sizes; markings extending on to head. Dorsal and anal fins without white external margins	*Genypterus blacodes*
	Maxillary extending to, or barely beyond, end of orbit. Eye subequal to, or larger than, snout; 5.4-6.8 in head. Body yellowish; with rather indistinct, usually angled brown bars; markings not extending on to head. Dorsal and anal fins with broad white external margins.	*Genypterus microstomus*

The above key follows conventional lines in adopting mouth size as a differentia. However, McCulloch (1914: 159) noted that Regan's specification for his species that the maxillary does not extend beyond hind margin of eye is not applicable to 5 of 8 *Endeavour* specimens; while in 1 of his examples of *G. blacodes* the maxillary ended below end of eye. McCulloch was inclined to allow more weight to *(i)* coloration, *(ii)* size of eye, *(iii)* size of interorbital. Regarding (iii), he reported that in his material of *G. blacodes* bony interorbital was 7.5-8.6 in head, about equal to eye; in *G. microstomus* 9.1-10.9 in head, not more than two-thirds eye: however, in the specimen of the latter species discussed below it is only 6.7 in head, and is 0.92 eye (with soft interorbital slightly exceeding eye).

Genus **GENYPTERUS** Philippi, 1857

Genypterus microstomus Regan, 1903

Genypterus microstomus Regan, 1903, *Ann. Mag. Nat. Hist.*, 7 (XI): 599. Type localities, Tasmania, Dunedin, Stewart Island.

Large examples. This species is noted by Scott (1962: 172) as reaching a length of 16 inches. Two much larger examples, secured in deep water off the continental shelf on the East Coast, were displayed in a Launceston fish shop in August 1970. The head of the smaller individual was preserved. Some of its dimensions are: weight 3 lb. 6 oz.; length 280 mm, length to preopercular border 208; greatest depth 130; snout 60; eye 45.5; iris 29; mouth 106; interorbital, bony 42, soft 47; barbel 133. Branchiostegals number 5.

Specifications of normal maximum length of the common ling, *G. blacodes* (*e.g.*, McCoy, 1879; Stead, 1906; Lord & Scott, 1924; Scott, 1962) centre round about 3 feet; McCulloch (1914) notes 'a very large specimen' 1125 mm long; Scott mentions an example 29 inches long that weighed 4 lb. 1 oz. However, fish reaching 5 feet, or more, and weighing 15-20 lb are said to be taken in Cook Strait and southward of it along the New Zealand coasts.

While *G. microstomus* is essentially a deep-water form — Scott (1962) notes that the record for South Australia is based upon specimens trawled in 350-450 fathoms in the Bight — *G. blacodes* is met with in quite shallow water, examples having been secured on our northern coast even in intertidal rock pools.

Family TETRAODONTIDAE

Some general observations on the Tasmanian members of this family, with key, are given in Part XI (1963), and in Part XIII (1965), which adds to the local list *Tetraodon firmamentum* Temminck & Schlegel, 1850, and notes the attribution to Tasmania by Scott (1962: 297) of *Sphaeroides glaber* (Freminville), 1873 (the relationship of which with *S. liosomus* Regan, 1909, is not altogether clear). The genus here rendered *Sphaeroides* appears in the Check-List (McCulloch, 1929: 429) as *Spheroides* Duméril, 1806, the reference being to *Zool. Analyt.*, 1806, index, p. 342, where it occurs as the latinized form of *Les Sphéroïdes* found on p. 108 of the same publication: the Check-List shows both as being preceded by the vernacular *Les Sphéroïdes* of Lacépède, *Hist. Nat. Poiss.*, ii. 1800: 22 However, Scott uses the spelling *Sphaeroides*, which is accepted also by Whitley (1968: 90), who attributes it to Anon., in *Allg. Lit. Zeit.*, Sept. 24, 1798: 676 *ex* Lacépède vernac.

An interesting record, from the west coast of King Island, of a member of the order Tetraodontoidea, *Lagocephalus lagocephalus* (Linné), 1758, new to Tasmania (and to Australia) has recently been made by Andrews (1970). The familial relationships of, on the one hand, *Tetraodon* Linné, 1758 [appearing as *Tetrodon* in the 12th ed., 1766], and, on the other hand, *Lagocephalus* Swainson, 1839 (together with the genera grouped round each of these by authors who refer them to separate families) are differently regarded in different quarters, there being three main treatments adopted: (i) one family, Tetraodontidae, is recognized, *e.g.*, by McCulloch (1929), Greenwood, Rosen, Weitzman & Myers (1966), Berg (1940) [as Tetrodontidae]; (ii) one family, Lagocephalidae, is recognized, *e.g.*, by Whitley (1968); (iii) two families are recognized, Tetraodontidae and Lagocephalidae, *e.g.*, by Schultz & Stern (1944), Munro (1955), Munro (1967) [as Tetrodontidae]. In both works cited Munro keys the Lagocephalidae as having 2 nostrils on each side, the Tetraodontidae (Tetrodontidae) as having 1 nostril on each side, or nasal sac open, appearing as 2 tentacles, the latter specification being expanded in the 1967 text (p. 552) to 'A single nostril on each side of snout and may have the form of a simple pit, a non-perforated cavity with a fringed rim sometimes produced into two fleshy flaps, a simple tube with a pore at its end, or a pair of thick tentacle-like flaps without opening'.

Genus **TETRAODON** Linné, 1758

Tetraodon armilla McCulloch & Waite, 1915

Tetraodon armilla McCulloch & Waite, 1915, *Trans. Roy. Soc. S. Aust.*, XXXIX: 475, pl. XV. Type locality, Great Australian Bight.

Counts, proportions. This midwater or deepwater species (the 12 described specimens, 22-140 fathoms; several localities) is rarely encountered in Tasmania: an example stranded at East Devonport, Devon has been recorded in Part XI (1963: 26). Examination of a specimen collected at Porky Beach, King Island, on 4 July 1970, by Mr M. T. Templeton (Q.V.M. Reg. No. 1970.5.21) yields some proportions differing from those given in the original account of the species.

Specifications of our fish are given in parentheses. D. 11-12 (12) [Scott (1962), 10-11]. A. 9-11 (9). P. 21 (21). C. 9+2 (9+2) Head 2.6-2.9 (2.84) in *Ls*. Snout 1.6-1.7 (2.11) in head. Eye 2.4-3.5 (1.88) in snout, 4.2-5.6 (3.96) in head. Largest dorsal ray 2.7-2.9 (2.59), caudal 1.2-1.4 (1.30) in head.

Some dimensions as TLs. Lengths to origins of dorsal, anal 765, 790. Dorsal base, between parallels 75, direct 84; anal 64, 73. Length to origin of pectoral 383, length of fin 160. Caudal 272. Longest dorsal ray 136, longest anal ray 109. Head 352. Snout 167. Eye 89. Interorbital 167. Length to vent 778. Depth (in parentheses, width) at gillslit 383 (370), at vent 235 (185); maximum 432 (346); caudal peduncle 110 (52). *Ls* 81, *Lt* 103 mm.

Coloration. Trunk above about midlateral line light brownish, except for a lighter saddle, extending from dorsal profile, behind to middle of pectoral, in front to middle of incomplete suprapectoral ring; this characteristic sharply delimited black line, in the form of about five-eighths of a circle, originates just in advance of upper part of gillslit, and arches high over pectoral base its chord 156 *TLs*, its height 105; rest of flank

whitish or white. Snout dark brown back to a line running from middle of lower border of orbit obliquely down to just behind lower lip; a subtriangular patch of brown bordering the light saddle on trunk, between this and eye another short light saddle; a short green spur backward from middle of posterior border of orbit; rest of lateral surface of head whitish or white. Ventral surface of head, trunk, tail wholly white, save for slight duskiness on caudal peduncle. Dorsal pale greenish, rays darker than membrane. Anal white. Pectoral colorless, except that about proximal one-sixth of uppermost 3 rays is dark brown, about proximal one-twelfth of remaining rays is dusky greenish. Lower 5 rays of caudal dark brownish, the lowest 2 throughout their length, the other 3 in distal half, or less; other rays touched distally with light brownish. The specimen is a female, the male having blue bars below and in front of eye, blue spots on head and flank, and a thin blue line outside the blue suprapectoral marking.

Spines. The only region without the small spines is the caudal peduncle; but very few occur on rest of tail.

REFERENCES

ALLEYNE, H. G. & MACLEAY, W., 1877: The ichthyology of the *Chevert* expedition. *Proc. Linn. Soc. N.S.W.*, **1,** 3: 261-81 and 321-59, pl. 2-4 and 10-17.

ANDREWS, A. P., 1970: A record of the oceanic puffer fish, *Lagocephalus lagocephalus* (L.) from King Island. *Pap. proc. roy. Soc. Tasm.*, **104:** 111-12, 1 pl., 1 fig.

BERG, L. S., 1940: The classification of fishes both recent and fossil. *Trav. Inst. Acad. Sci. U.R.S.S.*, **5,** 2: 86-517, figs 1-190 (in Russian, not seen). Edition in Russian and English issued by J. W. Edwards, 1947, Ann Arbor, Mich., U.S.A.

BLACKBURN, M., 1950: The Tasmanian whitebait, *Lovettia seali* (Johnston) and the whitebait fishery. *Aust. j. mar. freshw. Res.*, **1,** 2: 155-98, pl. 1-6, text-figs 1-3.

BLEEKER, P., 1877: *Atlas Ichth. Ind. Neerl,* **9.** (not seen).

BRIGGS, J. C., 1960: Fishes of worldwide (circumtropical) distribution. *Copeia,* 1960, **3:** 171-80.

GRAHAM, D. H., 1956: *Treasury of New Zealand fishes.* Wellington, A. H. & A. W. Reed.

GREENWOOD, P. H., ROSEN, D. E., WEITZMAN, S. H. & MYERS, G. S., 1966: Phyletic studies of teleostean fishes, with a provisional classification of living forms. *Bull. U.S. Mus. nat. hist.*, **131,** 4: 339-456, pls 21-23, text-figs 1-9, charts 1-32.

GÜNTHER, A., 1880: *An introduction to the study of fishes.* Edinburgh, A. & C. Black.

HUTTON, F. W., 1904: Editor, *Index Faunae Novae Zealandiae.* London, Dulau & Co.

JOHNSTON, R. M., 1883: General and critical observations on the fishes of Tasmania, with a classified catalogue of all the known species. *Pap. proc. roy. Soc. Tasm.* (1882): 53-144.

————, 1888: Notes with respect to the fresh water fishes, and the land and fresh water molluscs of King Island. *Pap. proc. roy. Soc. Tasm.* (1887): 76-8.

————, 1893: Further observations upon the fishes and fishing industries of Tasmania, together with a revised list of indigenous species. *Pap. proc. roy. Soc. Tasm.* (1892): 22-46.

KLUNZINGER, C. B., 1879: Die v. Muller'sche Sammlung australischer Fische in Stuttgart. *Sitzungsb. k. Akad. wiss* Wien, **80:** 325-40, pl. 1-9.

LORD, C. E., 1923: A list of the fishes of Tasmania. *Pap. proc. roy. Soc. Tasm.* (1922): 60-73.

LORD, C. E. & SCOTT, H. H., 1924: *A synopsis of the vertebrate animals of Tasmania.* Hobart, Oldham, Beddome & Meredith.

LYNCH, D. D., 1965: Changes in Tasmanian [whitebait] fishery. *Aust fish. Newsletter* [formerly *Fish. newsletter;* subsequently *Aust. fisheries:* Canberra], **24,** 14: 13 and 15.

MCCOY, F., 1879: *Prodromus of the zoology of Victoria,* dec. 3, pl. 29-30. Melbourne, Government printer.

MCCULLOCH, A. R., 1911: Report on the fishes obtained by the f.i.s. *Endeavour,* on the coasts of New South Wales, Victoria, South Australia and Tasmania. Part 1. *Zool. res. . . . Endeavour,* **1,** 1: 1-87, pl. 1-16, figs 1-20.

————, 1914: Report on some fishes obtained by the f.i.s. *Endeavour* on the coasts of Queensland, New South Wales, Victoria, South and south-western Australia. Part 2. *Biol. res . . . Endeavour,* **2,** 3: 77-165, pl. 13-24, text-figs 1-15.

————, 1915: Notes on, and descriptions of Australian fishes. *Proc. Linn. Soc. N.S.W:* **40,** 2: 259-77, pl. 35-38.

————, 1920: Studies in Australian fishes. No. 6. With a description of a new *Girellops* from the Kermadec Islands. *Rec. Aust. Mus.,* **13,** 2: 41-7, pl. 10-14, text-figs 1-3.

————, 1927: *The fishes and fish-like animals of New South Wales.* 2nd ed., with additions by G. P. Whitley. Sydney, Royal Zoological Society of New South Wales.

————, 1929: A check-list of the fishes recorded from Australia. *Aust. Mus. mem.,* **5** 1-4 (part 4, index 1930): i-ix + 1-534.

MCCULLOCH, A. R. & WAITE, E. R., 1915: The fishes of the Australian government trawling cruise 1914. *Trans. roy. soc. S. Aust.,* **39,** 455-76, pl. 12-15, text-fig. 1.

————, 1915: Some new and little-known fishes from South Australia. *Rec. S. Aust. Mus.,* **1,** 1: 39-78, pl. 2-7, text-figs 26-31.

MCDOWALL, R. M., 1964: A consideration of the question 'what are whitebait?' *Tuatara,* **12,** 3: 134-46, figs 1-4.

————, 1965: The composition of the New Zealand whitebait catch, 1964. *N.Z. j. Sci.,* **8,** 3: 285-300, text-figs 1-10.

————, 1966: Further observations on Galaxias whitebait and their relation to the distribution of the Galaxiidae. *Tuatara,* **14,** 1: 12-18, text-figs 1-2.

———, 1968: *Galaxias maculatus* (Jenyns), the New Zealand whitebait. *Fish Res. bull.,* 2 (new series).

MACLEAY, W., 1881: Descriptive catalogue of the fishes of Australia. *Proc. Linn. Soc. N.S.W.,* **5,** 3 (1880): 302-444.

MARSHALL, C. T., 1964: *Fishes of the Great Barrier reef and the coastal waters of Queensland.* Sydney, Angus & Robertson.

MUNRO, I. S. R., 1955: *The marine and fresh water fishes of Ceylon.* Canberra, Department of External Affairs (Halstead press).

————, 1957: Handbook of Australian fishes: instalment no. 7, pp. 29-32, in *Fish. Newsletter,* **16,** 1. [See note on title of periodical under LYNCH, D. D.].

————, 1958: Handbook of Australian fishes: instalment no. 28, pp. 113-16, in *Fish. Newsl.,* **17,** 10.

————, 1961: Handbook of Australian fishes: instalment no. 38, pp. 153-6, in *Fish. Newsl.* **20,** 4.

————, 1967: *The Fishes of New Guinea.* Sydney, Government printer.

PARROTT, A. W., 1959: *Sea Anglers' fishes of Australia.* Melbourne, Hodder & Stoughton.

PHILLIPPS, W. J., 1926: New or rare fishes of New Zealand. *Trans. proc. N.Z. Inst.* **56:** 59-37, pl. 87-92.

————, 1932: Notes on new fishes from New Zealand. *N.Z. j. Sci. Tech.,* **30,** 4: 226-34, figs 1-5.

POWELL, L., 1869: On four fishes commonly found in the river Avon, with a consideration of the question, what is whitebait. *Trans. proc. N.Z. Inst.,* **2:** 84-6, 2 figs.

REGAN, C. T., 1906: A revision of the family Galaxiidae. *Proc. Zool. Soc. Lond.* (1905): 363-84, pl. 10-13.

SCHULTZ, L. P., 1953: *in* Schultz *et al.,* Fishes of the Marshall and Marianas Islands, vol. 1, *U.S. nat. Mus. bull.,* **202,** i-xxxii + 1-685, pl. 1-74, figs 1-90.

SCHULTZ, L. P. & STERN, E. M., 1948: *The ways of fishes.* New York, D. van Nostrand & Co.

SCOTT, E. O. G., 1939-1970: Observations on some Tasmanian fishes: parts 1-15, 17 in this journal (part 16, 1969, in *Aust. Zool.,* **15,** 2). Contributions here cited: part 3, 1936: 113-29, text-figs 1-13; 4, 1939: 139-59, text-figs 1-2; 9, 1960: 87-101, text-fig. 1; 10, 1961: 49-65, figs 1-3; 11, 1963: 1-31, text-figs 1-6; 12, 1964: 85-106, fig. 1; 13, 1965: 53-65, fig. 1: 14, 1966: 93-115, fig. 1.

————, 1968: Certain nomenclatural proposals in Galaxiidae: a rejoinder. *Rec. Queen Vict. Mus.,* **29,:** 1-10.

SCOTT, T. D., 1957: A new blenny (Tripterygiidae) and pipefish (Syngnathidae) from King Island, South Australia. *Trans. roy. Soc. S. Aust.,* **80:** 180-3, figs 1-2.

————, 1962: *The marine and fresh water fishes of South Australia.* Adelaide, Government printer.

STEAD, D. G., 1906: *The fishes of Australia.* Sydney, W. Brooks & Co.

WAITE, E. R., 1895: New and rare fishes from Maroubra, New South Wales. *Proc. Linn. Soc. N.S.W.* (second series), **9,** 2: 215-77, pl. 17.

————, 1921: Catalogue of the fishes of South Australia. *Rec. S. Aust. Mus.,* **2,** 1: 1-208, pl. 1, figs 1-332.

WHITLEY, G. P., 1929: R. M. Johnston's memoranda relating to the fishes of Tasmania. *Pap. proc. roy. Soc. Tasm.* (1928): 44-68, pl. 2-4.

————, 1931: New names for Australian fishes. *Aust. Zool.,* **6,** 4: 310-44, pl. 35-37, 1 text-fig.

————, 1935: Whitebait. *Vict. Nat.,* **52:** 41-51, pl. 3, 2 text-figs.

————, 1940: Illustrations of some Australian fishes. *Aust. Zool.,* **9:** 397-428, pl. 30-31, 45 figs.

————, 1941: Ichthyological notes and illustrations. Aust. Zool. **10,** 1: 1-50, pl. 1-2, 32 figs.

————, 1944: Illustrations of some Western Australian fishes. *Proc. roy. zool. Soc. N.S.W,* (1943-44): 25-29, figs 1-6.

————, 1960: *Native freshwater fishes of Australia.* Brisbane, Jacaranda Press.

————, 1964: Presidential address: A survey of Australian ichthyology. *Proc. Linn. Soc. N.S.W.;* **89,** 1: 11-127.

————, 1968: A check-list of the fishes recorded from the New Zealand region. *Aust. Zool.,* **15,** 1: 1-10.

WHITLEY, G. P. & ALLAN, J., 1958: *The sea-horse and its relatives.* Melbourne, Georgian House.

WOODS, C. S., 1963: *Native and introduced fresh water fishes: Nature in New Zealand series.* Wellington, A. H. & A. W. Reed

————, 1964: Growth characteristics, pigmentation, and the identification of whitebait (*Galaxias* spp., Salmonoidea). *N.Z. j. mar. freshw., Res.,* 2, 2: 162-82, figs 1-13.

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ACANTHOCEPHALUS CRINIAE N. SP. (ACANTHOCEPHALA: ECHINORHYNCHIDEA) FROM THE CRICKET FROG, CRINIA TASMANIENSIS (GUNTHER)

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(Communicated by Dr J. L. Hickman)

With 5 text figures

ABSTRACT

The morphology of the adult and the egg of *Acanthocephalus criniae* n. sp. from *Crinia tasmaniensis* (Gunther), *C. signifera* Girard and *C. laevis* (Gunther) is described.

Information on the frequency and degree of infection of *C. tasmaniensis*, collected from Mt Wellington, Tasmania, is given.

INTRODUCTION

In 1968, Inglis, commenting on parasites recovered from 197 frogs from Western Australia, states (p. 164), 'in a very few cases an acanthocephalan was recovered from the intestine'. This appears to be the only report of adult Acanthocephala from Australian Amphibia. In contrast, there are a number of records of cystacanths from Australian frogs (Johnston and Deland, 1929; Johnston and Edmonds, 1948).

An examination of Tasmanian frogs has yielded a new species of *Acanthocephalus* Koelreuther, a genus hitherto known to occur only in Amphibia of the Northern Hemisphere.

MATERIALS AND METHODS

Two hundred and three specimens of *Crinia tasmaniensis* (Gunther) were collected from Mt Wellington during the period January 1969 to September 1969, anaesthetized, and dissected. The gut of each specimen was removed to a Petri dish where it was placed on a piece of filter paper moistened with frog Ringer solution. It was then slit open along its entire length and examined under a binocular microscope. Acanthocephala present were transferred to a crystal dish containing frog Ringer solution, and allowed to relax. The length and breadth of the metasoma of each worm was then measured. Eggs were removed from a number of gravid female worms and examined under phase contrast. The testes of several male worms were dissected out and treated with 0.004% colchicine for three hours and then immersed in hypertonic saline for half an hour. They were then fixed, squashed and stained in aceto-orcein. The remaining worms were fixed with Van Cleave's fixative (Chubb, 1962). Thirty specimens of each sex were cleared and mounted whole in Faure's Gum Choral (Gatenby and Beams, 1951). Other specimens were stained with alum carmine, cleared in clove oil and mounted in Canada Balsam. About 10 worms were embedded in Paraplast wax and sectioned at 6-12 μ. The sections were stained with Mayer's haematoxylin.

In addition, whole mounts of a number of Acanthocephala found in *C. tasmaniensis*, *C. laevis* (Gunther) and *C. signifera* Girard, collected in Tasmania by Dr J. L. Hickman (Department of Zoology, University of Tasmania) prior to the present study, were examined. Dr Hickman also kindly made available his data on the infection of *C. tasmaniensis* with *A. criniae*.

DESCRIPTION

The following description is based on a study of approximately 60 *A. criniae* n. sp. removed from the intestine of *C. tasmaniensis* collected on Mt Wellington, Tasmania. *Adult* (figures 1-3): Body small, male 1.4 × 0.3 - 3.6 × 0.8 mm., female 2.1 × 0.5 - 6.0 × 0.9 mm. Trunk aspinose, slightly flattened dorsoventrally. Body wall with numerous small hyperdermic nuclei. Lacunae system with main vessels lateral and reticular anastomoses. Neck short (0.06 - 0.10 mm. in length), without bulbous swelling, never cylindrical or spirally twisted. Proboscis ovoid (0.19 × 0.13 - 0.38 × 0.18 mm), slightly swollen, terminal, invaginable; 11 - 16 longitudinal rows of hooks, 4 - 5 hooks per row. Hooks increase in size from apex towards the middle and then decrease gradually towards the base; the spines 16 - 61 μ in length, the roots 9 - 48 μ. Receptacle cylindrical, 0.35 × 0.12 - 0.39 × 0.15 mm., double walled and inserted at the base of the proboscis. Ganglion at base of the proboscis receptacle. Two lemnisci, 0.4-0.5 mm. in length, more or less claviform, slightly longer than

Fig. 1.—Ventral view of proboscis of female showing spines and roots of hooks.

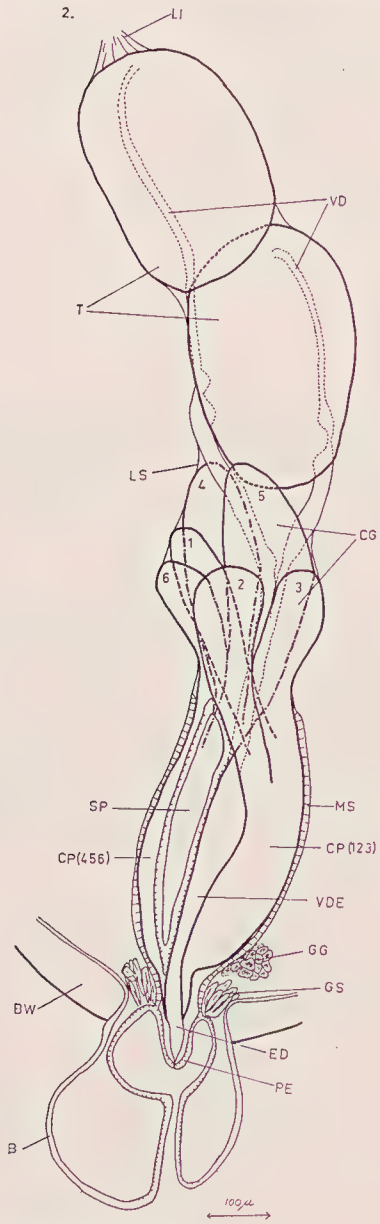

Fig. 2.—Male reproductive system.
B, bursa; BW, body wall; CG, cement gland; CP, cement passage; ED, ejaculatory duct; GG, genital ganglion; GS, genital sphincter muscle; LI, ligaments; LS, ligament sac; MS, muscular sheath; PE, penis, SP, Saefftigen's pouch; T, testes; VD, vas deferens; VDE, vasa deferentia.

the receptacle. Protonephridial organ absent. Testes oval, 0.20 × 0.14 - 0.42 × 0.34 mm., tandem, in mid-region of the body. Six cement glands, almost pyriform, close together in a rosette or two rows of three. Efferent duct of female 0.8 - 0.9 mm. in length. Genital pore in both male and female subterminal. Diploid chromosome number of 8.

Egg (figures 4, 5): Fusiform, flattened dorsoventrally, 67 × 23 - 86 × 25 μ in size. Four membranes around acanthor, the fertilization membrane with slight polar prolongations. Acanthors prior to hatching approximately 43 × 11 μ, after hatching approximately 47 × 15 μ. Integument, excluding apex, covered by spines arranged in approximate spiral rows. Group of 6 - 9 hooks (2.5 - 5.3 μ long) plus large, bifid, bulbous based hook (5.3 - 6.9 μ long) always present at apex.

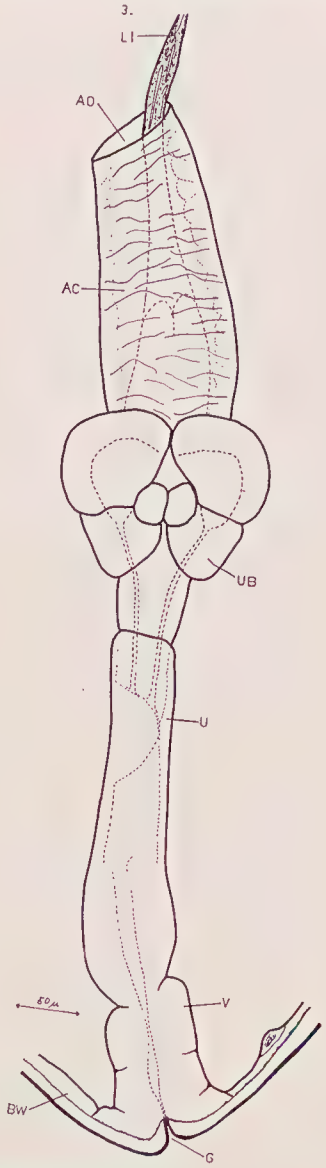

Fig. 3.—Female reproductive system.
AC, anterior chamber of uterine bell; AO, anterior opening of bell; BW, body wall; G, gonopore; LI, ligament; U, uterus; UB, uterine bell; V, vagina.

Type material: Holotype male, K228, allotype female, K228, and *paratypes*, K229, K230 (in glycerol/alcohol) deposited in the Tasmanian Museum, Hobart.

Location in the host: duodenum and ileum.

Type host: Crinia tasmaniensis (Gunther).

Type locality: Mt Wellington (3,800 ft), Hobart, Tasmania

Other hosts: C. laevis (Gunther). *C. signifera* Girard.

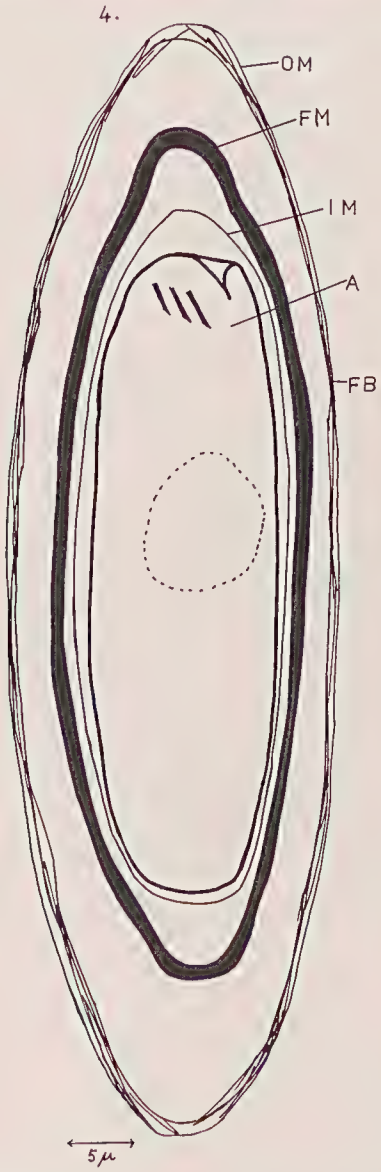

Figure 4. Mature egg.

A, acanthor (embryo); FB, fibrillar membrane; FM, fertilization membrane; IM, inner membrane; OM, outer membrane.

INFESTATION OF C. TASMANIENSIS WITH A. CRINIAE N. SP.

In the present investigation, 164 of the 203 *C. tasmaniensis* collected from Mt Wellington over the period January 1969 to September 1969 were found infected with *A. criniae* and from them a total of 484 (216 male, 268 female) worms were obtained. The degree of infection ranged from 1 to 9. The rather high incidence of infection agrees with that of frogs from the same locality collected by Dr J. L. Hickman over the years 1951 - 1967 (viz: 437:541, 1886, 855 male:1031 female, 1 - 39 worms per host).

DISCUSSION

The chromosome numbers of only a few Acanthocephala have been determined (see Makino, 1951). Two species of *Acanthocephalus, A. anguillae* (Müller) (syn. *Echinorhynchus proteus* Porta) and *A. ranae* (Schrank), have a diploid number of 8 (Makino, 1951 and John, 1957). From a study of meiotic metaphase plates and developing spermatozoa, the diploid number in *A. criniae* also appears to be 8. Four bivalents were found in most of the metaphase I plates, while 8 small chromosomes were observed in most of the metaphase II plates examined. Four rod like chromosomes were present in the developing sperm. No mitotic metaphase plate was found, so it was not possible to confirm that the piploid number is 8.

Yamaguti (1963) lists 32 species as belonging to the genus *Acanthocephalus*. Since then a further two species

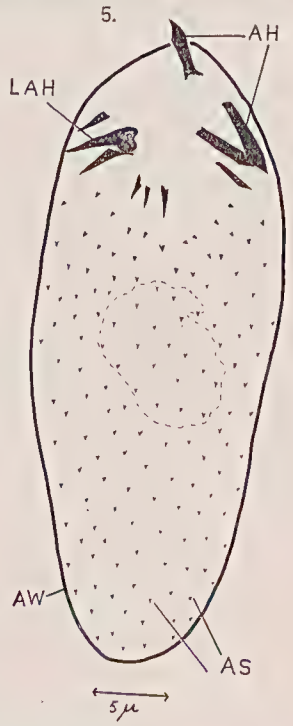

Fig. 5.—Acanthor or embryo.

AH, acanthor hooks; AS, acanthor spines; AW, acanthor wall; LAH, large acanthor hook.

TABLE I

CHARACTERISTICS OF SPECIES OF *PSEUDOACANTHOCEPHALUS* AND *ACANTHOCEPHALUS* WITH A PROBOSCIS ARMATURE SIMILAR TO THAT OF *A. CRINIAE* N. SP.

Species	Egg Size (μ)	Embryo size (μ)	Genital pore in female	Cement Glands	Testes (mm.)	Proboscis size in male (mm.)	Length of hook spines (μ)	Size of male (mm.)	Source of Information
A. criniae n. sp.	67×23—86×25	43×11	subterminal	6 in a rosette	0.20×0.14—0.42×0.34	0.19×0.13—0.25×0.16	16—61	1.4×0.3—3.6×0.8	
A. ranae	*110×13(d) 110—128(b)	—	*terminal(a)	*3 pairs in a tandem(c)(d)	*0.96×0.62(c) *0.65—0.75× 0.45—0.56(a)	0.45—0.50×0.3(d)	*61—95(b)	*4.5—9.0(b) 5—12(d)	(a) Engbert (1962) (b) Grabda-Kazubska (1962) (c) Kaiser (1893) (d) Lühe (1911)
A. falcatus	*74—87×17—21	38—47	*terminal	3 pairs in two rows of three	0.24—0.78 ×0.21—0.62	*0.25—0.32×0.15 —0.24	48—86	2.12—5.21× 0.43—1.00	Grabda-Kazubska (1962)
A. lucidus	*94—100× 24—26(a) *93—114× 24—32(b)	45—60× 13—15(b)	—		0.37—0.95× 0.32—0.65(b)	*0.35×0.3(a) *0.35—0.40× 0.18—0.29(b)	*70—88(a) 70—120 70—135(b)	*4.00(a) 4.5—7.3× 0.8—1.3(b)	(a) Van Cleave (1925) (b) Yamaguti (1935)
A. vancleavii	*54—72 ×12—18	—	—	*7 (based on one male only)	*slenderly elongate, complex measures 1.64×0.12	0.23×0.135	*30—105	*4.3×0.4	Hughes and Moore(1943)
(+) *A. tumescens*	—	—			0.41×0.27	*0.38×0.13	23—49	*5.8×0.4	Hartwich (1956)
P. bufonis	75—84× 23—27	—	—	—	*0.70—0.78× 0.47—0.53 close together midregion of trunk	*0.63×0.28—0.33	40—77	*4.2—8.1	Petrotschenko (1954)

FOOTNOTE: (+) Definitive host is a fish, those of other species are amphibians.
* Indicates where characteristic differs from same characteristic of *A. criniae* n. sp.

A. jacksoni Bullock (1962) and *A. madagascariensis* Golvan (1965) have been described. The only other genus found as adults in Amphibia is *Pseudoacanthocephalus* Petrotschenko. This genus has been considered to be a synonym of *Acanthocephalus* (Golvan, 1960; Baer, 1961). Therefore in the present study *A. criniae* n. sp. is compared with the species of both these genera.

In the pattern of its proboscis armature *A. criniae* n. sp. resembles the six species, *A. ranae, A. falcatus* (Froelich), *A. lucidus* Van Cleave, *A. vancleavii* Hughes et Moore, *A. tumescens* Linstow and *Pseudoacanthocephalus bufonis* (Shipley). However, it differs from each of these in a number of other characters (see Table I) and is considered to represent a new species.

ACKNOWLEDGMENTS

I am indebted to Dr J. L. Hickman, Zoology Department, University of Tasmania, for making available his collection of acanthocephalans from Tasmanian frogs, for his data on the infection of *C. tasmaniensis* and for advice given during the investigation.

REFERENCES

Baer, J. C. (1961): Embranchement des Acanthocéphales. *Traité de Zoologie,* Tome IV, p. 733-82. Pierre P. Grassé. Paris.

Bullock, W. L. (1962): A new species of *Acanthocephalus* from New England fishes, with observations on variability. *Journal of Parasitology,* Vol. **48,** p. 442-51.

Chubb, J. C., (1962): Acetic acid as a diluent and dehydrant in the preparation of whole, stained helminths. *Stain Technology,* Vol. **37,** p. 179-82.

Engbert, H. R. (1962): Der Froschratzer. *Microkosmos,* Vol. **51,** p. 19-24.

Gatenby, J. B. and Beams, H. W. (editors), (1950): *The Microtomists Vade-Mecum.* 11th Edition. Churchill, London.

Golvan, Y-J (1960): Le Phylum des Acanthocephala. Troisième note. La classe des Palaeacanthocephala (Meyer, 1931) (suite). *Annales de Parasitologie Humaine et Comparée,* Vol. **35,** p. 713-23.

Golvan, Y-J. (1965): Acanthocéphales de Madagascar recoltes par E. R. Brygoo. (Première note). *Annales de Parasitologie Humaine et Comparée,* Vol. **40,** p. 303-16.

Grabda-Kazubska, B. (1962): On the validity of the species *Acanthocephalus falcatus* (Froelich, 1789). *Acta Parasitologica Polonica,* Vol. **10,** p. 377-94.

Hartwich, G. (1956): Südamerikanische Acanthocephalen aus der zoolgischen Sammlung des Bayerischen Staates. *Zoologischer Anzeiger,* Vol. **156,** p. 299-308.

Hughes, R. C. and Moore, G. A. (1943): *Acanthocephalus vancleavii,* a new echinorhynchid worm from a salamander. *American Midland Naturalist,* Vol. **29,** p. 724-9.

Inglis, W. Grant (1968): Nematodes parasitic in West Australian frogs. *Bulletin of the British Museum (Natural History) Zoology,* Vol. **16,** p. 161-83.

John, B. (1957): The chromosomes of zooparasites 1. *Acanthocephalus ranae* (Acanthocephala: Echinorhynchidae). *Chromosoma,* Vol. **8,** 730-8.

Johnston, T. H. and Deland, E. W. (1929): Australian Acanthocephala. No. 1 *Transactions and Proceedings of Royal Society of South Australia, Vol.* **53,** p. 146-54.

Johnston, T. H. and Edmonds, S. J. (1948): Australian Acanthocephala No. 7. *Transactions Royal Society of South Australia,* Vol. **72,** p. 69-76.

Kaiser, J. (1893): Die Acanthocephalen und ihre Entwicklung. *Bibl. Zool.* H. 7. I. Teil, 136 pp. II Teil, 148 pp.

Lühe, M. (1911): Acanthocephalen *Die Süsswasserfauna Deutschlands, her ausgeben von August Brauer,* Heft 16, p. 17-19.

Makino, S. (1951): *An atlas of chromosome numbers in Animals.* 2nd Edition. Ames, Iowa. Iowa State College Press.

Petrotschenko, V. I. (1954): (Acanthocephala of Amphibia of S.S.S.R.) Rabot. Gel'mintol **75** - Let. Skrjabin, p. 505-17. *Contributions to Helminthology* translated by Dr A. Birron and Z. S. Cole.

Van Cleave, H. J. (1925): Acanthocephala from Japan. *Parasitology.* Vol. **17,** p. 149-56.

Yamaguti, S. (1935): Studies on the Helminth fauna of Japan. Part 8. Acanthocephala. *Japanese Journal of Zoology,* Vol. **6,** p. 247-78.

Yamaguti, *S.* (1963): *System Helminthum.* Volume V: Acanthocephala. Interscience Publishers, New York.

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THE CAINOZOIC GEOLOGY OF FLINDERS ISLAND, BASS STRAIT

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with

Appendix, 2 figures, 6 tables and 2 plates

ABSTRACT

Cainozoic sediments and volcanic rocks superficially overlie the mountainous Palaeozoic basement of Flinders Island and mainly form the coastal plains.

Marine deposits include Middle Pliocene to Recent near-shore and littoral coquinoid beds, and some Quaternary beds appear related to old marine stands at about 15-18 m., 4.5-6 m. and 0.6-1.5 m. above MHWS. Quaternary dune deposits are predominantly calcareous on the west coast and predominantly siliceous on the east coast, and show varying degrees of consolidation and soil development generally related to age. A Recent beach ridge and coastal barrier system is developed and lagoonal deposits include Pleistocene limestone and Recent peat. Non-marine gravel and grit deposits (including stanniferous and sub-basaltic deposits) were sometimes reworked by later marine incursions.

Scattered volcanic rocks include tuffs, alkali olivine-basalts and olivine-nephelinites, erupted from several centres roughly aligned along a north-westerly trend. The volcanism was largely Tertiary in age and some lavas are lateritised.

The Cainozoic history was initiated by faulting, tilting and uplifting of the Flinders Island block by early Tertiary time, with subsequent volcanism. During the Cainozoic, alternations of predominantly terrestrial or marine erosion and deposition on Flinders Island were related to fluctuating sea-levels, which influenced some faunal movements.

INTRODUCTION

This paper is based on observations made during visits to Flinders Island by the authors, supplemented by a study of aerial photographs, unpublished maps and reports, museum collections, and correspondence with a number of other workers. In particular, E. D. Gill and T. A. Darragh (National Museum of Victoria) assisted with radio-carbon and molluscan determinations and other matters, D. J. Taylor and A. C. Collins (Melbourne) identified foraminiferal faunas, and G. M. Dimmock (C.S.I.R.O.) supplied data and aerial photographs related to his soil mapping; other workers are mentioned in the text and acknowledgment section.

R. C. Kershaw visited the Island for 7 days in August 1957, when he collected from The Dutchman quarry and Nelson Lagoon drain and made geomorphological observations, particularly on the dune systems. F. L. Sutherland visited the Island for 3 days in April 1964, 5 days in April 1965 and 5 days in March 1970, when he sampled volcanic rocks, collected fossil material (from Holloways quarry, drains and waterholes on the Furneaux and Wingaroo Estates, and sites around Loccota and Lughrata), visited the Ranga cave, and made other general observations. The authors also examined material previously collected from Flinders Island and held in the Queen Victoria and Tasmanian Museums. Specimens collected by the authors are held in the Queen Victoria Museum, National Museum of Victoria and Tasmanian Museum, and thin sections of volcanic rocks are catalogued in the Tasmanian Museum. Specimen numbers refer to the Queen Victoria Museum collections, unless otherwise stated.

This paper deals with the Cainozoic geology of Flinders Island and some of the interpretations are based on geomorphological data to be presented more fully elsewhere (Kershaw and Sutherland, in press).

GENERAL

Flinders Island (lat. 40°S, long. 148°E, 65 Km. long, 40 Km. wide and 1,333 sq. Km. in area) is the largest island in the Furneaux Group, stretching across Bass Strait on the Bassian Rise connecting Victoria and Tasmania (Jennings, 1959a).

The Island is a mountainous basement ridge flanked by coastal plains. The western plain is mostly narrow, but carries important dune systems around Marshall Bay and Palana. The eastern plain is wider and more extensive, with a gentle slope marked by numerous dunes and lagoons and several residual basement hills. The steep mountain slopes ensure rapid run off and deep grit beds on the flanks are evidence of the erosive forces. However the dune systems have dammed the drainage to form extensive lagoons whose soils are an important agricultural asset. The dunes are generally stabilised and extensive modern blowouts are very

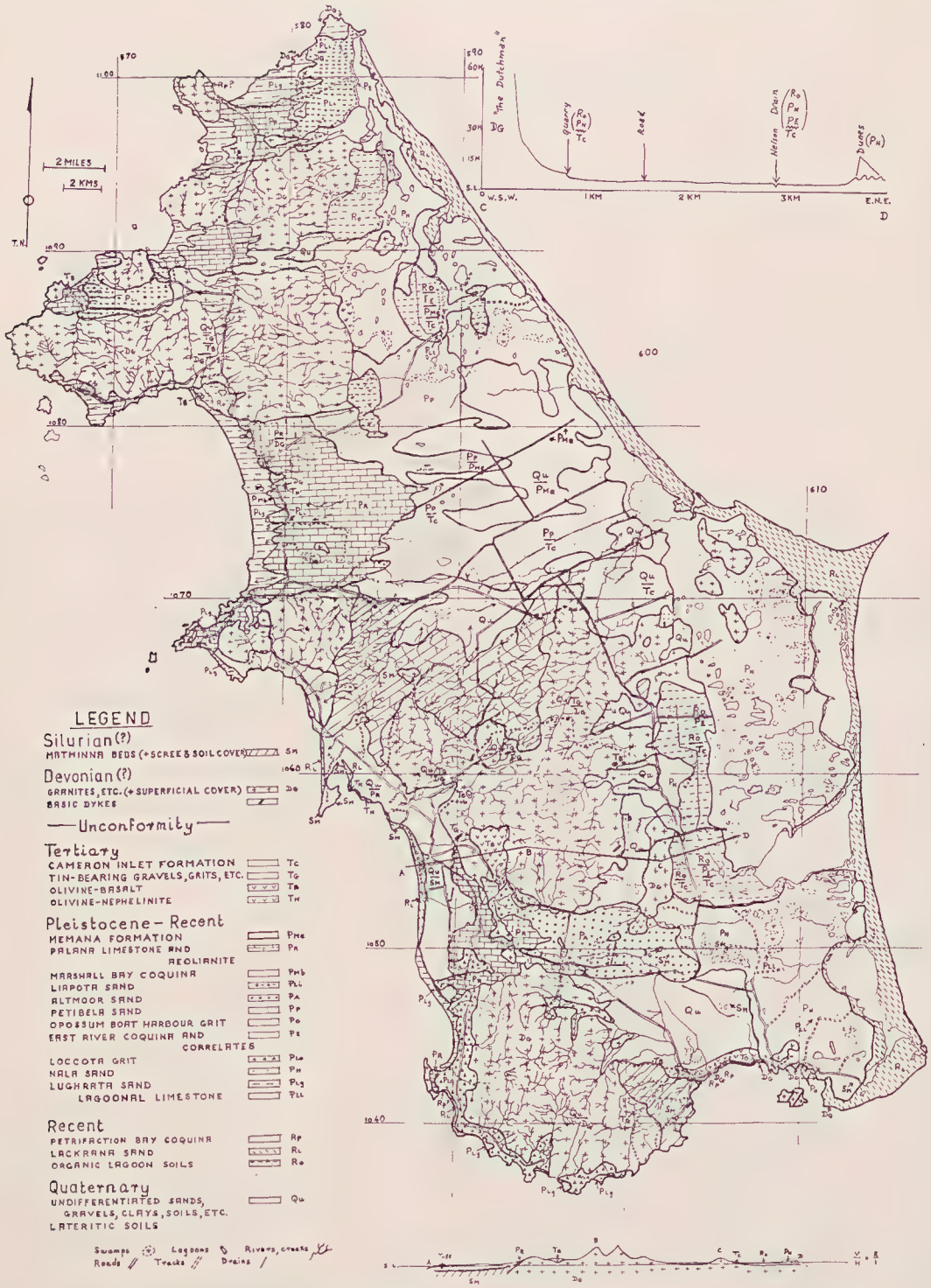


Fig. 1.—Generalised geology, Flinders Island. Modified from Dimmock (1957), based on unpublished Tasmanian Mines Department mapping by Blake (1947), Keid (1949), Everard (1950), and D. J. Jennings, field mapping by T. A. Darragh, D. M. Shanks and H. E. Wilkinson (National Museum of Victoria party, 1969), and mapping by F. L. Sutherland and R. C. Kershaw (1957-1970).

localised. Soils of the Island and their use are mapped and described by Dimmock (1957) and Pryor (1967), and limestone resources are discussed by Everard (in Hughes, 1957).

The geology of the Island consists of a Palaeozoic basement overlain with a superficial veneer of Cainozoic rocks (Figure 1). The basement consists of steeply folded quartzites and argillites, intruded by granite, associated with later basic doleritic dykes. The strata resemble Mathinna Beds of N.E. Tasmania (Siluro-Devonian, Spry and Banks, 1962). Carey (1953) postulated that these beds are folded along NNW-SSE trend, the Furneaux Anticlinorium, but most of the strikes observed on the Island by Blake (1947) and the authors were NNE-SSW to NE-SW in trend. Bores show that these beds extend under Cainozoic deposits around Whitemark (Hughes, 1959b). Granite forms most of the exposed basement, commonly in bold outcrops and sometimes including pegmatitic and aplitic phases (Flinders, 1814; Strzelecki, 1845; Gould, 1872; Johnston, 1879; Blake, 1935, 1947; Everard, 1950; Carey, 1953; Hughes, 1959a). It is regarded as an extension of the granite of N.E. Tasmania, intruded after the Tabberabberan Orogeny (Spry and Banks, 1962) and dated as Late Devonian (370 m.y.; McDougall and Leggo, 1965).

Recent preliminary investigations of the granitic rocks suggests that there are at least nine petrological types (D. I. Groves, pers. comm.). The largest area is covered by porphyritic biotite (muscovite) granites and adamellites with smaller areas of non-porphyritic biotite muscovite granites and adamellites and a limited area of biotite hornblende granodiorites and biotite granodiorites. The distribution of granite types, and the outcrop and projected shape of the sedimentary sequence together with its internal structure, suggests an essentially NNE trending regional structure.

The associated basic dykes tend to follow this regional trend. Preliminary petrological examination (F.L.S.) suggests that the dykes are mainly near-saturated dolerite resembling similar dykes intruding the Palaeozoic basement on Cape Barren Island and in eastern Tasmania (analysis 71, Spry and Banks, 1962, p. 283). They are probably late Devonian or Carboniferous in age.

CAINOZOIC STRATIGRAPHY

The Cainozoic rocks include marine, littoral, estuarine, aeolian, alluvial and residual sediments, with volcanic flows and pyroclastics. They are generally undisturbed tectonically, and the probable succession is summarised in Table 1.

TERTIARY NON-MARINE BEDS

Gravels, grits, sands, clays and lignites up to at least 6 m. thick, including stanniferous deposits, rest on the Palaeozoic basement of the Island (Blake, 1935, 1947; Keid, 1949; Jack, 1966). The lower levels of these

TABLE I. PROBABLE STRATIGRAPHIC SUCCESSION, FLINDERS ISLAND.

UPPER HOLOCENE	LACKRANA SAND (modern barrier growth). Alluvium, lagoon, beach and dune bone deposits.
——?——?——	LUGHRATA SAND. PETRIFACTION BAY COQUINA (post-glacial maximum sea?)
LOWER HOLOCENE	NALA SAND (old barrier reorientation). Ranga cave bone deposits. Tektite shower (?)
——?——?——	Frontal dunes & old barrier ridges. LOCCOTA GRIT. Lagoonal limestones. Tasmanian Aboriginal migration?
UPPER PLEISTOCENE	EAST RIVER COQUINA and correlates (4.5 m. sea?; old barrier growth). ?
	MARSHALL BAY COQUINA (15 m. sea?) LIAPOTA SAND. ALTMOOR SAND. PETIBELA SAND.
——?——?——	Trousers Point aeolianite ('Helicidae Sandstone' of Johnston). OPOSSUM BOAT HARBOUR GRIT. ?
LOWER PLEISTOCENE	PALANA LIMESTONE (older to younger dunes). MEMANA FORMATION (Werrikooian sea?). Stanniferous beds.
——?——?——	
UPPER PLIOCENE	
——?——?——	CAMERON INLET FORMATION (post-Kalimnan-Maretimo sea?) ('Turritella limestone' of Johnston?).
LOWER PLIOCENE ?	
——?——?——	'Kalimnan & older marine beds' (off-shore)? Lateritic profiles?
MIOCENE TO LOWER TERTIARY	ALKALI OLIVINE-BASALTS. OLIVINE-NEPHELINITES. 'Miocene marine beds'?
	Sub-basaltic tuffs. Sub-basaltic & 'Lower - Mid-Tertiary' stanniferous beds.
——Unconformity——	
PALAEOZOIC BASEMENT	GRANITIC INTRUSIONS, with basic dykes (Devonian?).
	MATHINNA BEDS (Siluro-Devonian?).

Fig. 2.—Distribution of Cainozoic volcanic features and marine formations on the Palaeozoic basement, Flinders Island. Based on field work by F. L. Sutherland, R. C. Kershaw, T. A. Darragh, D. M. Shanks and H. E. Wilkinson.

deposits may be well consolidated and probably represent Tertiary coastal drainage and pondage deposits. Similar sediments on Cape Barren Island are dated palynologically as Upper Oligocene/Lower Miocene, while post-basaltic material from 3.3 m. depth at Tanners Bay tinfield is tentatively dated as Pliocene-Pleistocene (Harris, 1965). Sub-basaltic stanniferous quartz boulder, grit and clay deposits are known at Canns Hill (Blake, loc. cit.). Some beds are pyritic and native sulphur is recorded from Tertiary sandstones on the Island (10.4%S; Tasm. Dept Mines, 1970).

TERTIARY VOLCANICS

Restricted outcrops of alkali olivine-basalts and olivine-nephelinites represent a number of small isolated eruptions. The thickest and highest exposure is 15 m. of lava N. of Ranga at 120 m. elevation, and the other exposures lie on the coastal plains. Outcrops show rough N.W. alignment with some cross trends, and some eruptions were explosive. The centres appear to be located mainly along Tertiary fault trends or near intrusive granite basement contacts (Figure 2).

Basaltic tuff containing numerous silicified logs was reported near Badger Corner (Johnston, 1879). This occurrence was not relocated, but small patches of weathered tuff (1966:34:14) were noted under basalt below high-tide level around Samphire River and 0.8 Km. E. These contain subrounded fragments of tachylytic basalt up to 0.8 mm. across and rare weathered peridotite (?) fragments. Silicified wood collected on the shore in this vicinity was one species referable to the Melaleuca (ident. A. Baker). Basaltic tuff was encountered in a bore at Whitemark Hotel, 4.5 m. below sea-level overlying limestone (Hughes, 1959b), and petrological examination (Appendix 1) suggests a possible hyaloclastite deposit.

Alkali Olivine-Basalts

(1) Adelaide Bay—Chew Tobacco Creek area.

The basalt is massive with cooling columns west along Adelaide Bay, but becomes strongly vesicular and amygdaloidal to the east and at Chew Tobacco Creek. Vesicles are coated with yellow or blue clay or sublimate and amygdales commonly contain carbonate, often forming botryoidal radiating masses weathering to limonite.

Petrologically (Appendix 1) the basalt resembles near saturated alkali olivine-basalts of Tasmania (Sutherland, 1969). It may have erupted from the explosive centre near Samphire River, probably flowing over a flat coastal plain extending to below present sea-level. It is overlain by undifferentiated Cainozoic sediments, Pleistocene Altmoor Sand and Recent Petrification Bay Coquina, and forms some lateritic soil W. of Samphire River. *See Addendum for further evidence of age.*

(2) Ranga—Whitemark area.

Massive basalt overlies a deep lead at Canns Hill here (Blake, 1935, 1947) apparently filling a N.W. trending valley. Outcrop pattern and basement topography suggest that this valley partly follows a N.W. fault line. A strong E-W lineation, probably a fault, crosses the southern part of the Darling Range and would intersect this line below the highest basalt, inferring location of the vent on such cross faulting.

Petrologically, the basalt is undersaturated alkali olivine-basalt, rich in glomeroporphyritic olivine and titan-augite and approaching a picritic type (Appendix 1; Analysis 1 Table 2). It is distinct from the Adelaide Bay flow, but its age relationships are obscure. It is overlain by Pleistocene Palana Limestone and Altmoor Sand and appears to be lateritised (Pliocene?) near Ranga.

TABLE 2. CHEMICAL ANALYSES & C.I.P.W. NORMS, FLINDERS ISLAND LAVAS.

ANALYSIS	1	2	NORM	1	2
SiO_2	43.16	41.85	Or	6.50	12.47
TiO_2	1.71	2.66	Ab	13.12	12.16
Al_2O_3	10.99	11.01	An	14.89	3.21
Fe_2O_3	4.13	4.90	Ne	5.00	14.46
FeO	8.67	8.75	Di	17.32	17.85
MnO	0.21	0.18	Ol	30.11	20.79
MgO	16.17	11.88	Mt	5.99	7.10
CaO	7.95	8.57	Il	3.25	5.05
Na_2O	2.64	4.59	Ap	1.02	6.01
K_2O	1.10	2.11	Ca	—	0.27
P_2O_5	0.43	2.75	Other	2.24	1.03
H_2O+	1.86	1.03			
H_2O-	0.38	—			
CO_2	—	0.12			
TOTAL	99.40	100.40		99.44	100.40

1. Alkali olivine-basalt (picritic phase). N. Ranga, Flinders Island; F. L. Sutherland, analyst.
2. Olivine-nephelinite (with peridotitic inclusions). N. Lughrata, Flinders Island; E. Kiss, analyst.

(3) Tanners Bay—Boat Harbour—Palana areas.
Small poor basalt exposures in north Flinders Island occur near Tanners Bay and in drill holes to the north 9 m. below late Tertiary-Pleistocene sediments (Jack, 1966; D. J. Jennings, pers. comm.), as pebbles brought to the surface by uprooted trees in dune limestone near Boat Harbour (coll. W. F. Ellis), and as float S.W. of Palana. The rocks are dense to amygdaloidal alkali olivine-basalt, sometimes carrying small peridotite xenoliths and accidental xenocrysts (Appendix 1). The question of separate extrusions or their source is uncertain from present exposures.

(4) E. Mt Leventhorpe area.
Small poorly exposed residuals of dense massive basalt here suggest localised extrusion of undersaturated alkali olivine-basalt (Appendix 1) onto the eastern coastal plain.

Olivine-Nephelinites

Outcrops of dense dark fine grained rock on Parrys Bay shore and float near Lughrata represent separate extrusions of olivine-nephelinites (Appendix 1; Analysis 2, Table 2). The Lughrata rock lies within granite basement, is found as pebbles in overlying Pleistocene Palana Limestone, and contains numerous small peridotitic xenoliths and xenocrysts in comparison to their relative rarity in the Parrys Bay rock.

Discussion

Ages of the Flinders Island volcanic rocks are not well established, but stratigraphic evidence suggests that most are pre-Pleistocene and probably Tertiary. They fall geographically between the Victorian and Tasmanian basalt provinces. They form an alkaline suite resembling the Older Volcanics of Victoria (Palaeocene-Lower Miocene; Singleton and Joyce, 1969) and the alkaline basalt associations of Tasmania (Eocene-Upper Cainozoic; Sutherland, 1969), both of which extend to opposite coasts of Bass Strait adjacent to Flinders Island.

The lavas range from strongly undersaturated alkaline rocks to mildly undersaturated basalt. Such rocks have been tentatively interpreted as products of segregation of parent alkali basalt magmas at depths of 35-75 Km. under Tasmania, with the nephelinitic associates representing products of more restricted and hydrous mantle melting at greater depths (see Sutherland, 1969). Preliminary electron microprobe analyses of the lherzolitic peridotite xenoliths in the rocks, indicate that they are inclusions of deep seated origin, possibly derived from the mantle (R. Varne, pers. comm., Appendix 1).

TERTIARY MARINE BEDS

These are exposed on the east coast and probably include 'Turritella' limestone at Heathy Valley (Johnston, 1879, 1887; Ludbrook, 1967). Johnston compared this fauna (see text, Table 3) with the Table Cape beds in N.W. Tasmania (Lower Longfordian; Quilty 1965), but considered that most species were different. It may represent the Cameron Inlet Formation of Middle-Upper Pliocene age (Darragh and Kendrick, 1970, and herein), or possibly remanié forms in the overlying Lower Pleistocene Memana Formation.

Bryozoal and cidaroidal marine limestones of Miocene age on Cape Barren Island (Crespin, 1945b) and Preservation Island (Tas. Mus. Colln. Y629; P. G. Quilty, pers. comm.) are unknown on Flinders Island, but may have been removed by erosion, or become covered. Derived foraminiferal faunas of probable Upper Miocene age in dune limestones at Ranga (described later) suggest the former presence of such marine beds around western Flinders Island. Fossil fish teeth, washed up on the east coast suggest Miocene-Pliocene marine beds off shore there. These include a right mandibular tooth of *Edaphadon sweeti* (1966:39:1; coll. H. O. Clifford, 1963; ident. T. Scott), recorded from basal Kalimnan in Victoria (Chapman and Pritchard, 1907), and a tooth of *Caracharodon megalodon* (1966:39:9; height 11.6 cm., breadth 9.8 cm.; coll. F. Henwood, 1914), recorded from Janjukian, Balcombian and Kalimnan (probably derived) in Victoria (Chapman and Pritchard, 1904).

Tertiary marine beds were apparently penetrated in Wingaroo No. 1 Bore, in shell beds between 3-24 m. depth, within alternating fine and coarse sands containing almost perfect shells (Nye, 1931). The fauna from 17-24 m. depth (Table 2) includes *Tylospira coronata, Turritella (Colpospira* sp.), *Miltha flindersiana* and *Placamen* cf *placida* (Singleton and Woods, 1934; Wilkins, 1962b; Gill, 1962; Ludbrook, 1967). Singleton and Woods considered that the faunas were very late Tertiary and the proportion of Recent species listed suggests correlation with the Cameron Inlet Formation, possibly passing up through Maretimo into Werrikooian and younger horizons above 17 m. depth. Comparison of species at different horizons in the bore (Tables 3 and 4) with the present day fauna, suggest a lagoonal shore to near-shore sandy to sandy mud shallow water facies down to 17 m. depth (Kershaw, 1958), in keeping with eastern Flinders Island today. Below 17 m. the fauna suggests a similar facies, but with reduction of exposure as found in semi-sheltered bays.

Cameron Inlet Formation (Darragh and Kendrick, 1970). This Pliocene formation was originally described by Wilkins (1962a) from The Dutchman lime quarry (grid 546N-028E, Dutchman Coquina) and from Nelson Lagoon Drain (grid 612N-040E, Cameron Inlet Marl). It is exposed in quarries, bores, drains and waterholes on the eastern coastal plain (Figure 2), lying below the Petibela, Nala, Wingaroo, Memama and Bootjack Soil Associations of Dimmock (1957), and may exceed 7.5 m. in thickness. It varies in lithology from sand, gravel, coquina to marl and the molluscan fauna (Table 3) includes *Tylospira (Singletonaria) gilli* (Marwick, 1960; Gill, 1962), *Miltha flindersiana* (Singleton and Woods, 1934; Wilkins, 1962b; Ludbrook, 1969), *Placamen* n. sp. (Gill, 1962) and *Eucrassatella deltoides* and *E. memanae* (Darragh, 1965).

The Dutchman quarry (now grassed over) exposed up to 1.2 m. of white friable limestone containing numerous thick shelled mollusca (Table 3; Plate 1, fig. 1) and extended down from 6.5 m. above MHWS. Wilkins (written comm., 1958) remarked 'I don't think anyone has yet noticed the horizon of phosphatic nodules at the lime quarry. Also associated Lovenia . . . and cidaroid spines. These I found around the deepest excavation . . . The nodules represent a disconformity of some sort and are comparable to the nodule beds in Victoria, though they look only faintly phosphatic'. A chemical analysis of the coquina gave 81% $CaCO_3$ and 0.12%

TABLE 3. PLIOCENE MOLLUSCA, CAMERON INLET FORMATION, FLINDERS ISLAND

Molluscan Identifications	Dutchman Quarry	Nelson Lagoon Drain	N. Patriarch -Memana Area	Wingaroo Bore N°-1 17-24 m.
GASTROPODA				
Alocospira aff. marginata (Lamarck)			x	
Amorena undulata (Lamarck)			x	
Bankivia cf. fasciata (Menke)	x			x
Cancellaria sp.				x
Cassis (Hypocassis) fimbriata (Quoy & Gaimard)			x	
Ctenocolpus australis (Lamarck)				x
C. terehellatas (Tate)			x	
Cupidoliva nymphala (Tate)	x			
Ericusa papillosa (Swainson)		x		
Eugyrina sp.				x
Floraconus anemone (Lamarck)				x
Fusus novae hollandiae (Reeve)				x
Gazameda gunni (Reeve)				x
Leiopyrga quadricingulata Tate			x	
Phasianotrochus sp.			x	
Phos. sp.			x	
P. senticosus (Linne)	x			
Polinices conicus (Lamarck)				x
P. aff. *cunninghamensis* (Harris)			x	
Sigapatella calyptraeformis (Lamarck)				x
Terebra sp.	x			
Turbo (Subninella) sp.	x			
Turritella (Colpospira) cf. *pagodula* Tate	x			
T. (Ctenocolpus) cf. conspicabilis Tate		x		
Tylospira coronata (Tate)	x	x	x	
T. (Singletonaria) gilli Marwick	x			
Umbilia hesitata Iredale			x	
PELECYPODA				
Bassina aff. *pachyphylla* (Jonas)			x	
B. cf. *paucirugata* (Tate)			x	
Cardium sp.				x
Chlamys cf. asperrimus (Lamarck)			x	
Cucullaea praelonga Singleton	x	x*	x	
Divalucina cumingi (Adams & Angas)			x	x
Donacilla erycinaea (Lamarck)				x
Dosinia sp.				x
Eucrassatella deltoides Darragh	x	x*		
E. memanae Darragh			x	
Eumarcia sp.		x		

Table 3. Pliocene Mollusca, Cameron Inlet Formation, Flinders Island (continued)

Molluscan Identifications	Dutchman Quarry	Nelson Lagoon Drain	N. Patriarch -Memana Area	Wingaroo Bore N°-1 17-24 m.
E. cf. fumigata (Sowerby)				x
Gari aff. *kenyoniana* (Pritchard & Gatcliff)			x	
Glycymeris convexa (Tate)	x	x*	x	x
G. halli Pritchard	x		x	x
Homalina cf. *mariae* (Tenison Woods, 1875)			x	
Katelysia rhytiphora (Lamy)				x
K. peronii Lamarck				x
Miltha flindersiana (Singleton & Woods)	x	x		x
Neotrigonia cf. *margaritacea* (Lamarck)			x	
Notocallista cf. *kingi* Gray	x			
Ostrea sp.		x		x
O. cf. *angasi* Sowerby			x	
O. arenicola (Tate)	x			
O. aff. *manubriata* (Tate)	x			
Phacosoma cf. *coerulea* (Reeve)			x	
Placamen sp.	x			
Placamen cf. *placida* (Philippi)	x		x	x
Proxichione moondarae Darragh			x	
Scaeoleda crassa (Hinds)				x
Tawera sp.	x			
Tucetilla radians (Lamarck)				x

Identifications by T. A. Darragh, E. D. Gill and R. W. T. Wilkins, with Wingaroo Bore No. 1 mollusca modified from Everard (1950), and some species listed from Darragh (1965), Dorman (1966) and Darragh and Kendrick (1970). Asterisks beside Nelson Lagoon Drain material indicates shells found both in the basal marl and overlying beds, including remanié forms in the Pleistocene East River Coquina; lack of asterisk indicates shells only from the basal marl. Material includes Tasm. Mus. Colln., Z 1371-1373, 1448-1475. R. M. Johnston (1879, 1887) lists the following amended species from the Tertiary beds of Flinders Island, but their exact status is uncertain; *Cucullaea (Cucullea) corioensis, Glycymeris (Cucullea) cainozoica, Nucula tumida, Turritella* sp., *Roxania (Cylichina) woodsi* and *Diplodonta subquadrata.*

P_2O_5(Everard, in Hughes, 1957). Matrix from the top of the coquina contained *Glandulina kalimnensis* Parr (common), *Rotalina hamiltonensis* Parr, *Nonion victoriensis* Cushman, *Massilina lapidigera* (Howchin and Parr) and an assemblage of large miliolids, polymorphines and rotalids, with many small lagenids, suggesting shallow water but open sea conditions (A. C. Collins, per E. D. Gill, pers. comm.). Broken and separated bivalves in the upper part of the coquina suggest possible reworking of a shallow water, near-shore deposit. Lateral equivalents to this reworked top of the coquina are apparently exposed in waterholes 0.8 Km. N. and up to 2 Km. E. to S.E. Here, the matrix varies from a gravelly quartz grit or sand, mixed with about 20% calcareous detritus, to predominantly calcareous detritus with rounded to angular quartz grains up to 5 mm. across; it sometimes forms hard calcrete.

The type exposure in the extreme N. end of Nelson Lagoon Drain was a 0.6 m. thickness of green glauconitic shelly marl, stratified as follows (R. W. T. Wilkins, written comm.):

a) 15 cm. *Cucullaea* horizon.

b) 23 cm. *Eumarcia* horizon.

c) 23 cm. *Cucullaea* horizon, with mixed 'rolled' and 'unrolled' shells, to water level; the top of the horizon was apparently eroded and bored and may have been exposed as old beach rocks. The position of this horizon has been studied further south in the Drain Section, 0.8 Km. N. of East River (grid 550N-050E), where the succession (Plate 1, fig. 2) is:

a) 0.4 m. lagoon soils with freshwater shells on the surface.

b) 1.4 m. sandy subsoil with grit (Nala Sand and Opossum Boat Harbour Grit?).

c) 0.3 m. shell bed with numerous Quaternary shells and remanié species from underlying beds (East River Coquina).

d) 15 cm. shelly sandy bed.

e) 30 cm. sandy bed.

f) 7.5 cm. green glauconitic marl, containing eroded bivalves, and excavated to water level. These beds underlying the East River Coquina are considered to represent the Cameron Inlet Formation and they extend down from about 2 m. above MHWS. The glauconitic marl (unit f) contains a similar molluscan fauna (Table 3) to The Dutchman coquina and may be a lateral, but deeper water facies. The upper members (units d and e) consist of friable, greenish grey, calcareous, silty sand, with sparse generally complete shells in unit (e) and numerous randomly orientated shells, predominantly *Cucullaea*, in unit (d). The disconformable base of the overlying East River Coquina contains forams of Kalimnan affinities, considered to be derived from the underlying sands, as described later.

Similar shell beds, mostly fine silty coquinoid limestones and sands, are exposed in excavations northwards from the type area of the Formation from Lackrana through Memana to the North Patriarch area, where they are disconformably overlain by the Lower Pleistocene Memana Formation. They may be buried under surface sands and soils up to over 2 m. deep, sometimes with organic or calcareous pans, and extend down from about 2-4 m. above MHWS. The western deposits inland from the North Patriarch area are largely friable coquinoid gravels and grits, with much fragmentary shell detritus, and commonly contain worn shells. The grit content tends to increase to a maximum in the westernmost exposures, where the deposits appear to represent near-shore to littoral facies. The molluscan fauna (Table 3) includes a predominance of oyster shells in places, and matrix material from the type locality of *Eucrassatella memanae* (Darragh, 1965) showed a foraminiferal fauna with high ratio of planktonics to benthonics, suggesting an inner shelf deposit (D. J. Taylor, pers. comm.). Skeletal fragments of whales, mainly vertebrae, have been recovered from excavated debris from drains around Memana. They include a skull (coll. H. O. Clifford and A. Dart, 1963; Nat. Mus. Vict., Colln. P23961-2), belonging to the genus *Ziphius* (Plate 2), but differing from any living species (J. Moore, per J. W. Warren, pers. comm.). Rare coral includes *Plesiastraea ananas* (Ellis & Solander) and *P. cf. versipora* (Lamarck), ident. M. R. Banks, from excavations passing into Pliocene beds at Lackrana and near North Patriarch drain, but the exact stratigraphic location is uncertain.

The eastward swing in distribution of the Cameron Inlet Formation between Memana and Lookout Hill (Figure 2), is influenced by the alluvial deposits of Leventhorpe Creek. Drain and dam excavations (to 7.5 m.) and bores (to 27 m. deep) in this area do not encounter the shell beds penetrated just to the east. Whether this is due to the existence of the alluvial fan as an original land barrier during the marine deposition or whether it results from later Pleistocene erosion of the marine beds is uncertain on present exposures. The small inswing in the Formation's distribution E. of Mt Leventhorpe, and its apparent absence on the southern coastal plain may correlate with basalt flows in these areas tending to act as barriers to the marine incursion.

The palaeontological evidence suggests that the Cameron Inlet Formation is Middle to Upper Pliocene in age (Darragh, 1970 and herein). Wilkins (1962a) assigned a probable post-Kalimnan, pre-Maretimo age to the molluscan fauna from The Dutchman and the lowest Nelson Lagoon Drain horizon, and stated 'The faunas . . . have a very strong Kalimnan aspect, but when the Pliocene species is ancestral to a modern one, the Flinders Island form is intermediate between the Kalimnan and living form, e.g. *Bankivia, Bassina.*' Some of the reworked upper parts and upper members of the Formation, however, may represent later deposits of the withdrawing Pliocene sea and may extend into the Maretimo in age. Palaeotemperature oxygen isotope measurements on *Ostrea* shells from The Dutchman quarry (Dorman, 1966), gave values up to 16.5°C and indicated a moderately warm Pliocene sea intermediate in temperatures between the tropical mid-Tertiary and cool Quaternary seas of Bass Strait.

CAINOZOIC LATERITES

Lateritic soils were mapped in several widely scattered localities on the Island (Dimmock, 1957) and also occur on basalt N.W. of Ranga (grid 536N-928E) and 3 Km. N.W. of Badger Corner. These consist mainly of siliceous sandy and gritty pisolitic ferricrete, and a ferruginised sandstone containing impressions of probable Pliocene marine shells was observed just west of soil site H101 of Dimmock (R. W. T. Wilkins, pers. comm.). Most of these occurrences appear to represent weak or semi-lateritisation, typical of conditions in Victoria during the later Pliocene and/or possibly in Pleistocene Interglacials (Gill, 1964). True lateritisation with development of pallid lower profiles may be present on the basalt at Ranga where Dimmock (1957) notes a clay underlying ferruginous material. Such profiles have been ascribed to at least the Lower Pliocene in Victoria (Gill, 1964).

QUATERNARY MARINE AND LITTORAL BEDS

Coquinoid deposits related to Quaternary seas occur on Flinders Island coasts to elevations of about 15 m., but generally less than 5 m., above MHWS. Well worn grit beds also occur and probably represent reworked littoral deposits.

Memana Formation

This Formation appears in the North Patriarch area (Figure 2, Plate 1, fig. 3) outcropping through, and encountered in excavations in soils of the Memana Association (Dimmock, 1957). It lies up to 5-7 m. above MHWS and is at least 4.5 m. thick. The following general succession was established at the E. end of No. 11 Road from excavation debris and communication with the property owners.

a) surface gravelly or loamy sand, up to 0.6 m. thick.

b) clay horizon, 5-30 cm. thick.

c) hard coquinoid calcrete or calcareous bands and nodules, 15-45 cm. thick.

d) gravelly and gritty shelly sands and sandstone, up to 1.5 m. thick.

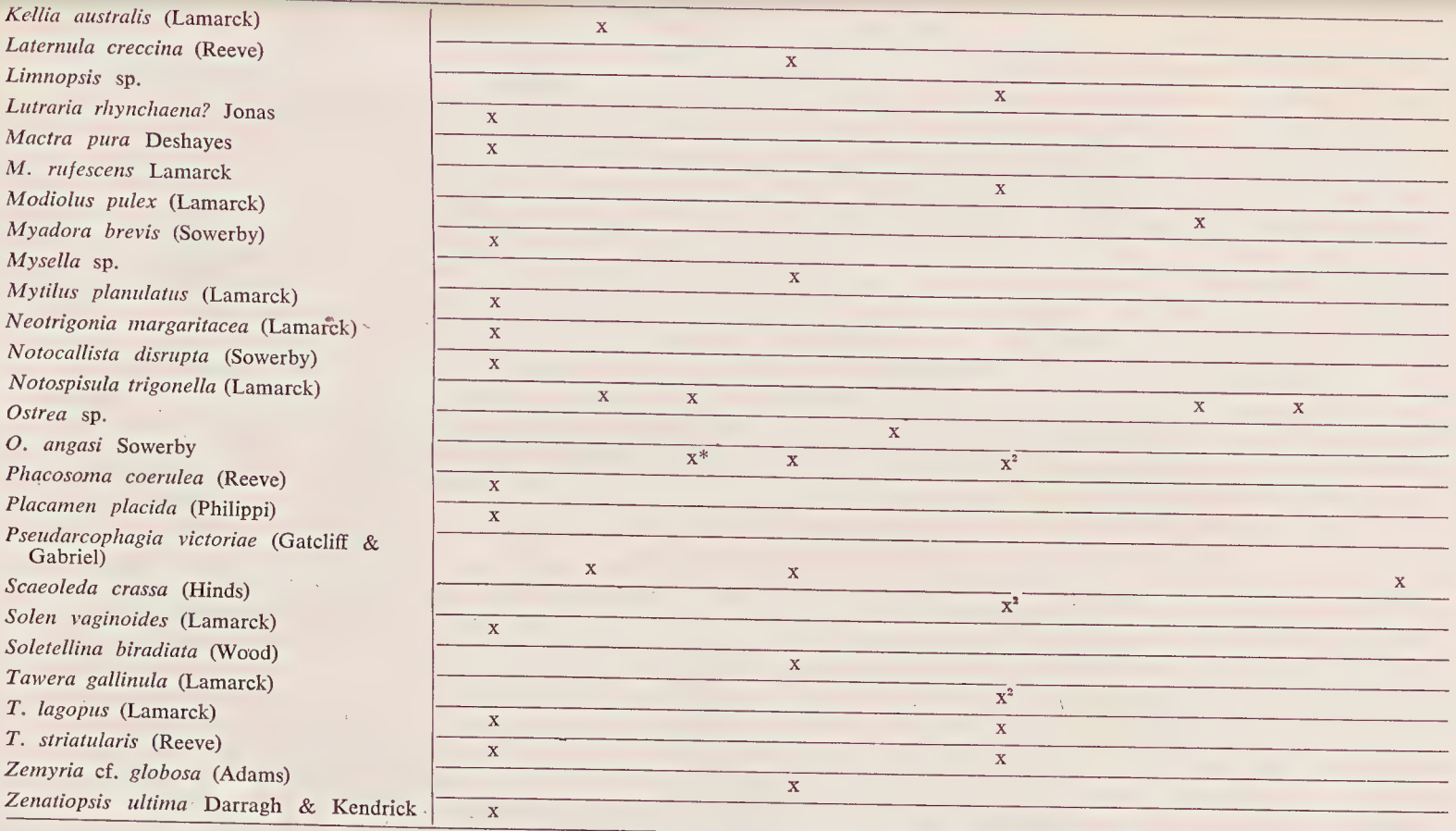
TABLE 4. QUATERNARY MOLLUSCA, MARINE BEDS, FLINDERS ISLAND. (LOWER PLEISTOCENE-RECENT).

Molluscan Identifications	Memana Formation	Marshall Bay Coquina	East River Coquina	Coquina, Arthur River Estuary	'Oyster Bed' Johnston, 1879	Wingaroo 0—4.5	Coquina, South of Trousers Pt (lagoon)	Petrifaction Bay Coquina	Coquina, South of Trousers Pt (dune)	Coquina, Yellow Beach
GASTROPODA										
Acmea scalarina Cox		x	x*			x		x		
Amblychilepas crucis (Beddome)						x				
Amorena undulata (Lamarck)	x									x
Assiminea tasmanica Tenison Woods		x								
Astele subcarinatum Swainson	x					x				
Austrocochlea sp.					x					
A. adelaidae (Philippi)					x			x		x
A. concamerata (Wood)								x	x	x
A. constricta (Lamarck)		x						x		x
Austrodrillia beraudiana (Crosse)			x							
Austroginella muscaria (Lamarck)			x*			x				
Bankivia fasciata (Menke)	x		x*			x				
Battilariella estuarina (Tate)				x						
Bedeva paivae (Crosse)	x		x*		x			x		
Bembicium auratum (Lamarck)								x		x
B. nanum (Quoy & Gaimard)									x	
Bullaria botanica (Hedley)				x						x
Cacozeliana granaria (Kiener)			x*	x			x			
Capulus violaceus Angas								x		
Chemnitzia mariae Tenison Woods			x							
Chiazacmea flammea (Quoy & Gaimard)								x		
Cingulina spina (Crosse & Fisher)			x							
Clanculus plebejus Philippi					x					
Cominella eburnea (Reeve)	x									
Cominella sp.				x						
Conicella porcellana (Tate & May)		x*								
Coxiella sp. N.M.				x						
Ctenocolpus australis (Lamarck)	x					x				
Cylichnina sp.					x					
C. iredaleana (Hedley)			x					x		

Cymatiella verrucosa (Reeve)						x				
Dentimitrella sp.			x*							
D. lincolnensis (Reeve)			x*							
D. menkeana (Reeve)										x
D. tayloriana (Reeve)			x*							
Diala lauta Adams			x	x	x					
D. pagodula Adams			x*							
Eubittium lawleyanum (Crosse)				x						x
Floraconus anemone (Lamarck)			x*							
Herpetopoma sp.			x							
Hypotrochus monachus (Crosse & Fischer)			x*							
Isoclanculus dunkeri			x*	x	x					
Kimberia sp.					x					
Lenamaria cf. *nitida* (Sowerby) N.M.			x*							
Macrazafra atkinsoni (Tenison Woods)			x							
Mesoclanclus ochroleucus (Philippi)								x		
Micrastraea aurea (Jonas)										x
Microcolus dunkeri (Jonas)										x
Munditia australis (Kiener)										x
Nassarius sp.						x[1]				
Nevia spirata (Lamarck)	x									
Niotha pyrrhus (Menke)	x		x*	x				x		x
Notocochlis sp.	x									
Notosetia sp.					x					
N. nitens (Frauenfeld)								x		
Ophicardelus sulcatus (H. & A. Adams)		x								
Parcanassa pauperata (Lamarck)						x		x		x
Pervicacia ustulata (Deshayes)	x									
Phasianella australis (Gmelin)										x
Phasianotrochus irisodontes (Quoy & Gaimard)								x	x	
Pleuroploca australasia (Perry)				x						
Plicaginella sp.	x					x				
Polinices conicus (Lamarck)										x
Proxiuber sp.	x									
Pseudamycla dermestoidea Lamarck			x*			x[1]				

TABLE 4. QUATERNARY MOLLUSCA, MARINE BEDS, FLINDERS ISLAND (LOWER PLEISTOCENE-RECENT—continued)

Molluscan Identifications	Memana Formation	Marshall Bay Coquina	East River Coquina	Coquina, Arthur River Estuary	'Oyster Bed' Johnston, 1879	Wingaroo 0.-45 m.	Coquina, South of Trousers Pt (lagoon)	Petrifaction Bay Coquina	Coquina, South of Trousers Pt (dune)	Coquina, Yellow Beach
Pyrazus sp.?						x[1]				
P. ebeninus (Bruguière)										N.S.
Salinator fragilis (Lamarck)									x	
Sigapatella calyptraeformis (Lamarck)	x					x[2]				
Sydaphera purpuraeformis (Kuster)	x									
Tavaniotha munieriana (Crosse)								x		
Turritella sp.?					x					
Zeacumantus cerithium (Quay & Gaimard)				x						
Z. diemenensis (Quoy & Gaimard)		x		x				x		x
PELECYPODA										
Anadara trapezia (Deshayes)										N.S.
Anapella cycladea (Lamarck)							x		x	
Bellucina crassilirata (Tate)			x*							
Chlamys asperrimus (Lamarck)	x		x			x[2]				
Codakia sp.						x[2]				
Cuspidaria sp.						x[2]				
Divalucina cumingi (Adams & Angas)	x									
Donacilla angusta Reeve						x				
D. cuneata (Lamarck)		x						x	x	
Electromactra antecedans Iredale		x								
Equichlamys bifrons (Lamarck)	x		x*							x
Eumarcia fumigata ? (Sowerby)						x[1]				
Fulvia tenuicostata (Lamarck)	x		x*	x		x	x			
Glycymeris sp.						x[2]				
G. flammeus (Reeve)	x									
Homalina deltoidalis (Lamarck)		x		x						
H. mariae (Tenison Woods)				x						
Hormomya erosa (Lamarck)		x		x			x	x		x
Katelysia peronii (Lamarck)		x		x				x		
K. rhytiphora (Lamy)			x*	x		x[2]	x			x
K. scalarina Lamarck										x



Identifications by R. W. T. Wilkins, R. C. Kershaw, E. H. Turner and T. A. Darragh, with listing from Nye (1931) and Darragh and Kendrick (1970). Material listed under 'Oyster Bed', Johnston, 1879, was identified by R. C. Kershaw from Johnston's Arthur River Estuary Collection (some labelled Oyster Bed), held in the Tasmanian Museum (amongst Z861-Z917). N.M. against molluscan species indicates a non-marine dweller. Asterisked species from the East River Coquina indicate shells found in the type section in Nelson Lagoon Drain. Species numbered 1 and 2 amongst the Wingaroo mollusca indicate shells found in the 0-3 m. and 3-4.5 m. depths respectively in the Wingaroo Bore (Nye, 1931). N.S. indicates shells found not *in situ*. Material includes Tasm. Mus. Coll. Z1476-1539. R. M. Johnston (1879) lists the following species (amended) exposed from the inland sand dunes and lagoons of Flinders Island, but their exact status is uncertain; *Bankivia fasciata (varians), Philine angasi? (aperta), Neotrigonia (Trigonia) margaritacea Tucetilla (Pectunculus) striatularis? (rubens), T. (P.) radians? (roseus), Salinator (Ampullarina) fragilis, Anadara (Arca) trapezia, Scaeoleda (Leda) crassa, Fulvia (Cardium) tenuicostata (tenuicostatum), Glycymeris (Cucullea) cainozoica (remanié?), Glycymeris (Pectunculus laticostatus (remanié?), Cucullaea (Cucullea) corioensis (remanié).* Examples of the modern molluscan fauna of the Furneaux Group are listed in Johnston (1879), May (1958), Turner (1970) and the Tasmanian Museum Molluscan Register.

TABLE 5. FORAMINIFERA, QUATERNARY DEPOSITS, FLINDERS ISLAND

Formaniferal Identifications	Palana Limestone	East River Coquina	Marshall Bay Coquina, Coquina, S. of Trousers Point (dune foot)
Ammonia beccarii (Linne)	x	x	
Anomalina sp.	x		
Cibicides mediocris (?) Finlay	xR		
C. reflugens (Montfort)	x		
C. victoriensis (?) Cushman	xR		
Clavulina multicamerata Chapman	x		x
Discorbinella biconcava (Jones & Parker)	x		x
Discorbis dimidata (Jones & Parker)	x		x?
Elphidium advenum (Cushman)	x		
E. argenteum Parr	x	x	x
E. crassatum Cushman	xR		
E. crispum (Linne)	x		
E. macellum Fichtel & Moll	x	x	x
cf. Epistominella pulchra (Cushman)	x		
Globigerina bulloides d'Orbigny	x		
Globigerinoides conglobulata (Brady)		xR	
Guttulina yabei Cushman & Ozawa	x		
Miliolinella oblonga (Montagu)	x		
Nonion victoriense Cushman		xR	
Operculina victoriense Chapman & Parr	xR		
Parrellina imperatrix (Brady)	x		
Patellinella inconspicua (Brady)	x		
Polystomellina clathrate (Brady)	x		
Quinqueloculina lamarkiana d'Orbigny	x		
Rectobolivina sp.	x		
Rosalina australis (Parr)	x		x
Spiroloculina angulata Cushman	x		x
S. subimpressa Parr	x		x
Streblus beccarrii d'Orbigny	x		
Textularia sp.	x		
T. pseudogramen Chapman & Parr	x		x
Triloculina striatula Parr	x	x	x
T. trigonula Lamarck	x		

Identifications by Crespin (1945a), Ludbrook (1965) and D. J. Taylor. R. indicates probable remanié species.

e) shelly silts, soft sands and limestone, 1.5-3 m. thick.
f) hard gravelly and gritty coquinoid limestone, at 4.2-4.5 m. depth.

The basal coquinoid horizon (unit f) contains numerous worn shells, including remanié Pliocene species, associated with well preserved *Bankivia fasciata* and appears to represent a near-shore or littoral deposit. It is found at shallower depths to the south and eventually the horizon gives way laterally to the underlying Cameron Inlet Formation.

The shelly soft beds (unit e) are well exposed around No. 2A Road, between Nos 11 and 2 Roads. The molluscan fauna here (Table 4) is essentially modern, but includes rare *Zenatiopsis ultima* (Darragh and Kendrick, 1970) and some remanié Pliocene shells, and suggests a probable Lower Pleistocene (Werrikooian) age. The fauna suggests shallow off-shore bay conditions, and some *Chlamys asperrimus* shells bore growths of barnacles (cf. *Balanus variegatus,* ident. E. C. Pope).

The upper members (units d and c) contain strongly worn shells and in some places resemble littoral deposits. The succession to the N.E. thus appears to encompass deposits of transgression and following regression of the Lower Pleistocene sea into a large bay. However, the role of possible later Pleistocene transgressions (represented by deposits elsewhere on the Island) in this area is uncertain, and they may have reworked part of the upper succession. The northerly extent of the Formation is not precisely known, but it extends into the Wingaroo area amongst the shell horizons overlying the Tertiary beds at the 17 m. depth in the Wingaroo bore (Nye, 1931; T. A. Darragh, pers. comm.).

Marshall Bay Coquina

This coquinoid siliceous calcarenite is poorly exposed E. of Palana Road, N. of Lughrata (grid 760N-793E) at about 15 m. above MHWS, disconformably overlain by Lughrata Sand and apparently disconformably overlying Palana Limestone. Traces of similar shelly rock have been noted elsewhere around Lughrata (D. I. Groves, pers. comm.).

It contains up to 25% worn and broken mollusc shells, and the molluscan fauna (Table 4) suggests a beach deposit with sheltered sandy bay environment (common *Hormomya erosa, Katelysia peronii),* with sand flats *(Donacilla, Notospisula)* and shallow water off-shore with sandy bottom *(Electromacta, Pseudarcophagia).* The matrix is greyish fawn, tough, compact calcrete, weathering white. It contains shell fragments, worn foraminifera and about 30% angular to rounded quartz grit in abundant calcareous cement. The foraminiferal fauna (Table 5) was reported as ' . . . similar to that living on the sea floor in Bass Strait today . . . The worn nature of the specimens suggests it is a 'displaced' fauna, but the specific content does not indicate that it is derived from Tertiary sediments' (D. J. Taylor, pers. comm.).

The rock probably represents a littoral deposit associated with a 15-18 m. level (MHWS). The fauna, degree of lithification and elevation suggest a Pleistocene Interglacial age, probably not younger than early Riss/Würm.

East River Coquina

This coquinoid sandy silt, 30-38 cm. thick, is exposed in Nelson Lagoon drain (grid 550N-050E), N. of East River between 2-3.5 m. above MHWS. It disconformably overlies the Cameron Inlet Formation and is disconformably overlain by at least 1.7 m. of sands and lagoonal soils, including Nala Sand and Opossum Boat Harbour Grit (?), (Plate 1, fig. 2).

The fauna contains numerous Quaternary shells (Table 4) and remanié species from the underlying bed (Table 3) mainly in a mixed transitional zone to 8 cm. thick. Numerous marine bivalves, sometimes packed tightly, include generally complete oysters apparently *in situ.* The formation top is well defined, but with slight reduction in shell numbers, and no marine shells occur in the overlying deposits. The fauna represents a mixed assemblage, apparently an accumulation on a bay floor, and includes species normally living on sea-weeds *(Bankivia),* near-shore or inter-tidal species *(Katelysia, Cacozelliana)* and off-shore species *(Fulvia, Equichlamys).* In most cases a sandy mud or sandy environment is indicated, but with some nearby rocks as suggested by presence of algal dwellers and *Floroconus anemone.*

The matrix is sandy silt largely composed of quartz, both clear angular and rounded frosted grains, and shell fragments, The foraminiferal fauna of a basal sample included *Nonion victoriense, Globigerinoides conglobata* and several other Kalimnan species (D. J. Taylor, pers. comm.). However, in view of remanié molluscan fauna, these are probably remanié forams from underlying Pliocene horizons.

Other sites with numerous remanié mollusca (including *E. deltoides,* Darragh, 1965) occur in water hole excavations E. of The Dutchman between Memana road and Nelson Lagoon drain, and these excavations include shark's teeth and whale vertebrae (1966:39:7; coll. F. Rhodes). Matrix from the top of such coquina contained a sparse extant foraminiferal assemblage (Table 5, D. J. Taylor, pers. comm.). The Formation extends S. of East River and N. to Lackrana (Figure 2).

The Coquina may be an off-shore Pleistocene marine deposit, probably related to the 4.5 m. level (MHWS), correlated with the later Riss/Würm Interglacial. Precise dating awaits more detailed investigation. Erosion of underlying beds by such a sea is indicated by the remanié fauna, and similar erosion occurs off-shore at present as *Cucullaea* valves commonly wash ashore. However, the presently exposed disposition of the Formation is also compatible with possible marine flooding of an elongate coastal inlet through Cameron Inlet. Probable equivalent or near-equivalent deposits to the East River Coquina include coquinas near Loccota, Arthur River and Wingaroo.

The Loccota deposits include an exposure in an old lagoon bank, S. of Trousers Point (grid 419N-894E) with a fauna (Table 4) rich in *Fulvia tenuicostata* (1965:38:76) in a friable darkish sandy silt matrix. The deposit is up to 1.5 m. above MHWS and is interpreted as an off-shore facies *in situ* on a shallow sandy mud floor of a former Pleistocene Interglacial or Interstadial sea bay. A further coquina at similar elevation, in a drain S. of Ferguson Jetty (grid 472N-896E), contains common *Anapella cyclyadea,* suggesting deposition on sandy mud flats in sheltered to estuarine waters. The matrix here is now tough, light coloured sandy calcrete containing about 30% predominantly angular quartz grains with foraminiferal and other organic remains.

A coquina, 0.8 m. thick, is exposed in a cliff on the west shore of Arthur River estuary opposite Beagle Spit (grid 998N-838E) at 3-4 m. above MHWS. It disconformably overlies Pleistocene sand (Liapota Sand?) and is disconformably overlain by unconsolidated sand. The coquina may be related to the 'Oyster Bed' of Johnston (1879), which shows similarities in molluscan fauna (Table 4), but which was reported at a slightly higher elevation. A thick, tightly packed oyster bed was exposed in the estuary's west bank over twenty years ago, but has since largely washed away (J. Robinson, pers comm.) and this spot almost 0.7 Km. N. of the described section probably represents Johnston's site. The succession exposing the coquina is:

a) Cliff top, 5.4 m. above MHWS with shallow depression of former lagoon.

b) blackish sandy soil with limestone pieces from (c)—30 cm.

c) limestone without shells—av. 15 cm.

d) fine compact unlithified sand—1.1 m.

e) white gritty sand, densely packed with shells—15 cm.

f) white sand with reduced grit content, few shells including *Laternula* in life posture—35 cm.

g) white sand, shells densely packed—35 cm.

h) yellow and red-brown sands, lower levels covered with detritus.

The beds are exposed 50 m. horizontally and at one point horizon (d) lenses out and more than 30 cm. of limestone (c) rest on the upper shell bed of the coquina (e-g). Beds are level, but end abruptly against grey sand (Liapota Sand?). At the southern extremity this sand is sharply contrasting and contains carbonaceous and compacted grit bands 2-5 cm. thick. At the northern extremity the sand is firstly grey, then yellow and grey. Some mixing of materials is inferred across the near-vertical extremities, but with little disturbance, and it seems to represent a former stream site.

The molluscan fauna (Table 4) is appropriate to sheltered waters such as an estuary or sheltered bay. It includes species preferring mud *(Ostrea, Zeacumantus),* sandy mud *(Laternula, Homalina, Katelysia peronii, Bullaria),* sand *(Soletellina, Katelysia rhytiphora)* to brackish mud *(Batillariella). Hormomya* lives in compacted sandy mud and grit with weeds as exists at present in Arthur River estuary, and *Fulvia tenuicostata* is an off-shore sandy bottom species. Thus, the assemblage suggests variable conditions with some species washed in, and *Niotha* and *Bedeva* preying on the fauna. *Coxiella,* an euryhaline mollusc, indicates a marked change in conditions.

Sand from horizon (e) shows (A. C. Collins, per E. D. Gill, pers. comm.): 'The floatings are almost entirely *Streblus* sp. the same form as that from Lake Pertrobe. I think, with a few rare and poorly developed *Elphidium* and a lot of coxiellid gastropods. This of course amounts to brackish water conditions, estuarine or lagoonal. I found nothing that could be taken as a purely marine form, suggesting there was little or no influx of tidal waters. The sand grains are well rounded and frosted, there were a few plates of mica, and some vegetable debris'.

Thus, the presence of *Coxiella* and brackish water micro-fauna requires interpretation and it is considered that a brackish lagoon temporarily established on the upper shell bed of a marine transgression. This transgression probably relates to the 4.5 m. level (MHWS), correlated with a later Riss/Würm Interglacial sea. Shell beds, met at depths below 6.5-7 m. above MHWS under the lagoonal soils around Wingaroo (Figure 2; Table 4; Nye, 1931) probably represent further related deposits of this sea.

Petrifaction Bay Coquina

This coquina, 5-8 cm. thick, is exposed on Petrifaction Bay shore slightly above MHWS, disconformably overlying basalt (Plate 1, fig. 6). The coquina contains about 60% shell material in loose matrix of coarse rounded to angular quartz grit, with fine silty micaceous and calcareous detritus (1966:35:6).

The shelly fauna (Table 4) is that of a sheltered bay with sandy mud or mud, grits and stones, and is the same as in the similar present local environment. The Coquina appears to be a shore-line or near-shore deposit related to a former sea-level about 0.6 m. above MHWS of probable Holocene, or possibly late Pleistocene age. Similar coquinas at equivalent elevations are known on the granite shore up to 2 m. above MHWS at Palana, below the surface at Wingaroo (Nye, 1931), in Arthur River Estuary and near Trousers Point, but it is uncertain that they are all equivalent deposits.

The Arthur River deposit is exposed 46 m. along the cliffs, N. of the 3-4 m. MHWS coquina, at 2.2 m. above MHWS as a lens 11 m. long overlain by 0.6-0.9 m. of sand to the cliff top. It contains a fauna of Recent aspect with common *Austromylitus erosus* (Lamarck) and is virtually identical to that of the present sandy shore.

The Trousers Point coquina, 5 cm. thick, is exposed at the base of a fore-dune at about 1.5 m. above MHWS, in the bay south of the point (grid 418N-893E). It contains a mixed molluscan fauna (Table 4) favouring a sandy bay with some shelter or reduction of wave action of wide sandy flats, with *Bembicium* and *Austrocochlea* apparently washed in. It includes carapace of *Philyra laevis* (Bell), the littoral smooth pebble crab (1966:38:3; ident. A. Dartnell), and the deposit appears to represent a high tide accumulation. The matrix is loose yellow-fawn foraminiferal calcareous sand with minor amounts of mica flakes and small quartz grains. The foraminiferal fauna (Table 5) is rich, beautifully preserved and identical with those in sea-floor samples taken from Bass Strait today, being very similar to that listed by Brady, 1884, from 'Challenger Station 162' off East Moncoeur Island in 73 m. of water (D. J. Taylor, pers. comm.). This suggests an assemblage more that of an inner shelf deposit with a possible depth range of 15-90 m. and this puzzling feature may be due to a later Holocene sea strand washing into Pleistocene deeper water deposits at this site.

Opossum Boat Harbour Grit

This siliceous grit, at least 8 m. thick, is exposed in Opossum Boat Harbour cliffs (grid 430N-110E, Plate 1, fig. 4) resting on granite basement and disconformably overlain by Nala Sand. It is dark brown, moderately

consolidated, friable coarse grit containing well rounded to subangular quartz grains in a carbonaceous organic matrix. Further exposures of such grit occur on Cameron Inlet shore and underlie much of the area covered by Nala Sand. Teeth of the sperm whale *Physeter* were found in similar gritty sand, just above high tide level on nearby Great Dog Island (coll. J. Nield; 1966:39:12).

The degree of consolidation and development of organic matrix suggest a Pleistocene age. The Grit probably represents detrital accumulations from erosion of highland areas, possibly prior to, but with extensive marine reworking during, the Riss/Würm Interglacial and/or a Würm Interstadial.

QUATERNARY DUNE DEPOSITS

These include extensive coastal dunes on the west and east coasts with some relatively small inland deposits. Calcareous dune deposits characterise west coast series whereas siliceous dunes characterise east coast series.

Palana Limestone

This is predominantly calcified aeolian calcarenite, at least 9 m. thick in places, occurring on the western Flinders Island coast and typically exposed in the Palana, Lughrata and Ranga districts. It is variable in thickness and outcrops from below sea-level to elevations about 150 m. above. It overlies Palaeozoic basement; disconformably overlies Cainozoic sands and lavas, and disconformably underlies Lughrata Sand. On weathering it develops deep red-brown soils of the Ranga Association (Dimmock, 1957).

The limestone is generally cream to buff, with fragments of mollusc shells, bryozoans, echinoid spines, holothurian remains, algal remains (including *Lithothamnium),* poorly preserved foraminifera and quartz grains; secondary calcification is prominent and organic remains may be almost completely replaced (Crespin, 1945a; Everard in Hughes, 1957; Ludbrook, 1965). Chemical analyses (Everard, loc. cit.) generally show 60-95% $CaCO_3$, with a mean at 83%, except at Parrys Bay—Blue Rocks area where more siliceous rocks average about 70% $CaCO_3$.

Early workers considered the limestones to be marine deposits, but Dimmock (1957) considered them dune aeolianites, a view supported by the author's geomorphological studies Foraminifera in the limestones (Table 5) have been dated as upper Pliocene-Pleistocene (Crespin, 1945a), Pleistocene (Ludbrook, 1965) and 'derived from the Tertiary' (D. J. Taylor, pers. comm.). The latter forms were described from Ranga as 'poorly preserved, badly worn and fragmental foraminifera, bryozoa and mollusca. Foraminiferal determination was difficult at specific level, though several species of *Cibicides* were present *(C. victoriensis* and *C. mediocris),* at least one species of *Elphidium (E. crassatum)* and some fragments which could be assigned to *Operculina victoriensis.* From my knowledge of the Bass Basin (both marginal and offshore drilling) I am of the opinion that these faunas were derived from Middle to Upper Miocene sediments . . . one could say Balcombian to Mitchellian with a slight possibility of Kalimnan. The Ranga dune limestone is totally different to faunas which I regard as Quaternary'.

The available evidence suggests that the calcareous dunes from which the Palana Limestone developed cover a range in time. Some of the dunes, as at Ranga, possibly originated in the late Tertiary or early Pleistocene when lower sea-levels associated with glaciation would have exposed vast areas of Upper Tertiary calcareous marine beds. The limestone is cut by the 4.5 m. level (MHWS), correlated with the later Riss/Würm Interglacial sea, and this with other geomorphological considerations suggests a Lower Pleistocene, pre-Riss/Würm age for most of it.

The Palana Limestone appears to include a more siliceous younger dune member, which may represent a separate formation on very detailed mapping. This siliceous aeolian calcarenite, at least 3 m. thick, is exposed S. of Trousers Point (grid 420N-890E, Plate 1, fig. 5) overlying granite basement. It contains species of 'Helicidae' and represents the 'Helicidae' Sandstone of Johnston (1879). Johnston's term, however, appears also to partly include the more calcareous Palana Limestone. Dunes of the aeolianite outcrop from sea-level to about 30 m. above, and were mostly observed in the Loccota district.

It is coarse to fine grained, cross-bedded, fawny calcarenite. It is consolidated, but friable, generally lacks the lithification shown by much of the Palana Limestone, and contains moderate to considerable amounts of angular to rounded quartz grit, with some feldspar and rare biotite. Samples contain reworked and worn foraminiferal species similar to those listed from the Upper Quaternary (?) fauna isolated from the coquina in the foredune S. of Trousers Point (Table 5; D. J. Taylor, pers. comm.). The dunes are cut by the late Quaternary 0.6-1.5 m. level (MHWS) and also appear planed by the 4.5 m. level (MHWS), suggesting, with degree of consolidation and calcareous content, an age at least pre-late Riss/Würm.

Liapota Sand

This siliceous aeolian sand, at least 6 m. thick, is typically exposed around The Quoin and forms the chief soil type in the Liapota Association (Dimmock, 1957). It disconformably overlies Palana Limestone, is disconformably overlain by Lughrata Sand, and inundates granite hills up to 180 m. in elevation.

It is white to grey sand passing down into darker coloured strongly developed carbonaceous organic 'B' horizons, suggesting a Pleistocene age. Geomorphological evidence suggests dunes associated with old Pleistocene shore lines, at least Riss/Würm in age.

Altmoor Sand

This siliceous aeolian dune sand, at least 2.3 m. thick, is exposed at Ranga at elevations mostly 30-60 m. above sea-level, and forms the chief soil type in the Altmoor Association (Dimmock, 1957). It disconformably overlies Palana Limestone and undifferentiated Cainozoic non-marine beds. It is dark to light grey sand with organic carbonaceous horizons and is a similar deposit to Liapota Sand. The developed soil profile suggests Pleistocene age, and geomorphological evidence suggests possible association with old Pleistocene shorelines, at least Riss/Würm in age.

Petibela Sand

This siliceous gritty aeolian sand with clay, at least 2 m. thick, occurs on the east coast at elevations 5-30 m. above MHWS, and forms the chief soil type of the Petibela Association (Dimmock, 1957). It dis-

conformably overlies Pleistocene (?) stratified sandy clay loams, clayey grits and grits, and is disconformably (?) overlain by Nala Sand. It forms marked parabolic dunes whose elevation above sea-level and presence of some organic accumulation with development of slight organic pan, suggest a late Pleistocene age, probably Riss/Würm.

Nala Sand

This gritty unconsolidated aeolian sand, up to 1.5 m. thick, occurs on the east Flinders Island coast at about 4.5-8 m. above MHWS, and is the chief soil type of the Nala Association (Dimmock, 1957). It disconformably overlies Opossum Boat Harbour Grit, Petibela Sand and older Pleistocene deposits, and is disconformably overlain by Lackrana Sand.

The formation forms well developed parabolic dunes Its material probably derives in part from underlying grits and sands and in part from siliceous material blown inland from the shallow eastern coastal shelf, when exposed by sea-level lows during late Würm and/or possible early Holocene time.

Lughrata Sand

This unconsolidated aeolian calcareous sand, at least 3 m. thick, occurs on the west Flinders Island coast, typically around Lughrata, and forms the chief soil type of the Lughrata Association (Dimmock, (1957). It disconformably overlies Palana Limestone, Loccota Grit and Marshall Bay Coquina and is disconformably overlain by Lackrana Sand. It is dominantly small shell fragments, with some organic matter and concretionary carbonate in the lower horizons, and ranges from 27-83% $CaCO_3$ (Dimmock, loc. cit.). A whale paddle bone was recovered from the sand at Loccota (J. Nield, coll. 1940; 1966:39:13).

The formation forms well developed parabolic dunes and forms the calcareous west coast counterpart of the siliceous east coast Nala Sand dunes. The dunes are found on benches cut at about 4.5 m. above MHWS which are correlated with a late Riss/Würm Interglacial sea. They show freshness of form and immaturity of soil profile which lead Jennings (1959b) to assign a young age to similar dunes on King Island. They are probably mostly early to mid-Holocene in age. The most recent coastal foredunes of this system probably range into the Upper Holocene and hence may be equivalent in age to part of the Lackrana Sand.

Lackrana Sand

This unconsolidated siliceous aeolian littoral sand, up to 3.6 m. thick, forms a beach ridge system fringing Flinders Island coasts. It is typically developed around Lackrana, and forms the chief soil type of the Lackrana Association (Dimmock, 1957). The formation disconformably overlies Nala Sand and older deposits, forming well developed ridges on the east coast with minor occurrences on the west coast. The parent material contains 3-5% $CaCO_3$ in minute shell fragments and there is only incipient development of soil profile (Dimmock, loc. cit.).

Such ridges on N.W. Tasmania are regarded by Gill and Banks (1956) as Holocene in age and possibly associated with a Post-Glacial thermal maximum, and such levels on the Tasmanian coast (Davies, 1959) are found to have beach ridges formed continuously to the present day. The Flinders Island ridges probably had a similar history to those of Tasmania and southern Victorian coasts (Jenkin, 1968), forming mainly in the Upper Holocene. The beach ridge at Whitemark has developed, at least in part, in historic time, as witness discarded bottles and timber buried within it.

QUATERNARY LAGOONAL AND LUCUSTRINE DEPOSITS

Extensive Quaternary dune building was associated with considerable lagoonal development on both the east and west coasts. Soils on old inland lagoons, probably Pleistocene, include those of the Metta Association (Dimmock, 1957) as found S. of Lookout Hill, E. of Mt Leventhorpe and W. of The Dutchman. Recent organic lagoon soils are mapped as the Wingaroo Association (Dimmock, 1957), while Everard (1950) refers to Recent lagoonal limestone deposits.

Grey limestone with small streaks of carbonaceous matter and numerous minute gastropods occurs in a quarry on Wingaroo road, 8 Km. N. of Emita (Ludbrook, 1965). The fauna (Table 6) indicates deposition in a marginal lake or mud-flat under non-marine conditions, probably in the Pleistocene. An extensive platform of dense, tough limestone with numerous gastropods, recently exposed under sandy soil near Wingaroo gate, presumably represents a Pleistocene lagoonal deposit at a higher level than the present Wingaroo lagoon floor.

Friable and porous limestone, over 2.1 m. thick is exposed in Holloways Quarry, 3.2 Km. N.E. of Lady Barron at about 2-5 m. above MHWS. Its base is not exposed and it appears disconformably (?) overlain by Nala Sand.

A section in the N.W. part of the quarry is:

(a) 1.2 m., pale greyish limestone (1965:33:21).

(b) 0.23 cm., pale greyish limestone with numerous small dark nodules (1965:33:20).

(c) 4.6 cm., pale greyish limestone (1965:33:19).

(d) 23 cm., pale yellowish limestone (1965:33:18), quarry floor.

The unit boundaries are gradational and all units contain freshwater gastropods. The fauna (Table 6) suggests variations in conditions in that there was some water movement at times. *Lenamaria, Simlimnea* and *Glyptanisus* are found in ponds and their abundance indicates predominance in this type of environment; *Austropyrgus, Revisessor* and *Beddomena* are more appropriate to creeks and rivers. It appears that water movement was prevalent during deposition of unit (d), but nearly absent during deposition of unit (c). Still lagoonal waters, possibly with occasional water influxes were prevalent during accumulation of unit (b), allowing development of nodular bodies and water flow probably increased during formation of unit (a). Land shells *(Egilomen, Pedicamista)* are expected as these species live in vicinity of such environments and could be washed in.

Chemical analyses from different horizons in the Quarry (Everard, in Hughes, 1957) range from 55-91% $CaCO_3$. The highest $CaCO_3$ is shown by unit (d) and the lowest by a sample that includes the nodule horizon (b). The nodules appear to be carbonate and siliceous (?) material and are not noticeably phosphatic (178 p.p.m. phosphorus in nodule, cf. 87-99 p.p.m. for matrix; det. F. Brown).

TABLE 6. QUATERNARY MOLLUSCA. LAGOONAL LIMESTONES, FLINDERS ISLAND

Molluscan Identifications	Lagoonal Limestone Holloway's Quarry					Lmst. N. of Emita
	Bed d	Bed c	Bed b	Bed a	R. W. T. Wilkins Colltn.	
Assiminea tasmanica (Tenison Woods)?						x
Coxiella sp.					x	
Freshwater species						
Austropyrgus buccinoides (Quoy & Gaimard)	x	x	x		x	
Beddomena lodderae (Petterd)	x		x		x	
Glyptanisus atkinsoni (Johnston)		x	x		x	
G. meridionalis (Brazier)					x	
Lenamaria sp.			x			
L. sp. *(juveniles)*				x		
L. pyramidata (Sowerby)		x			x	
Revisessor turbinatus (Petterd)	x		x	x	x	
Simlimnea sp?						x
S. gunni (Petterd)		x				
S. neglecta (Petterd)		x				
Valvatasma tasmanica (Tenison Woods)?				x		
Land Species						
Egilomen barrenense (Petterd)			x		x	
Geminoropa sp.? (juvenile)						x
Pedicamista caesa (Legrand)					x	
Thyrasona diemenensis (Cox)?						x

Identifications by R. C. Kershaw (Holloway's Quarry) and Ludbrook, 1965 (limestone, N. of Emita).

Similar Pleistocene lagoonal deposits may be represented by soft earthy limestone N. of Lady Barron (Dimmock, 1957, p. 27), from the Five Mile Lagoon (Wingaroo) area (Everard, loc. cit.) and from 0.4 Km. E. of Franklin Village jetty, Cape Barren Island (1964:35:5; coll. R. W. T. Wilkins).

QUATERNARY ALLUVIAL DEPOSITS

These are most prominent flanking highlands of Palaeozoic basement rocks such as the Strzelecki and Darling massifs.

Loccota Grit

This siliceous grit and gritty clay, at least 1.5 m. thick is exposed around Loccota in creeks draining into Fotheringate Bay and forms the chief part of the Loccota Soil Association (Dimmock, 1957). It overlies granite basement, and in part at least, appears to disconformably (?) overlie Palana Limestone. It contains a high percentage of angular quartz grit and represents alluvial accumulations of granite detritus from Strzelecki Peaks. Part, or most, of the material was probably derived and deposited during the Würm Glacial. Where grits with cemented organic 'B' horizons occur, as at Big River (Dimmock, loc. cit.), these probably represent older deposits.

UNDIFFERENTIATED QUATERNARY DEPOSITS

These include beds of waterworn grits, gravels, sands and clays, including stanniferous and organic enriched deposits in the Whitemark-Blue Rocks, Tanners Bay-Killiecrankie, Bootjack and Memana areas (Dimmock, 1957; Jack, 1966). Pebbles and crystals of gem quality topaz and associated minerals occur in such beds at Killiecrankie (Gould, 1872; Petterd, 1911). Some deposits resemble Opossum Boat Harbour Grit and probably represent alluvial accumulations reworked by Pleistocene seas. Some angular quartz grits and clay resemble Loccota Grit, as in the Whitemark-Blue Rocks area, at the mouth of the Leventhorpe Creek and elsewhere. These are probably alluvial deposits formed in areas exposed by withdrawal of the last Pleistocene Interglacial or Interstadial sea or in areas unaffected by Pleistocene marine transgression.

Old drainage deposits include an exposure in road cuts on the Whitemark-Memana Road (grid 630N-

913E) of a boulder bed 70 m. across and at least 2.4 m. thick. This occupies an east-west trending stream profile cut into underlying Mathinna Beds. The deposit consists mainly of rounded fragments of Mathinna Beds up to 23 cm. across, but includes fragments of hornfels and quartz and in places passes into a coarse sandy matrix.

Minor areas of siliceous dune ridges occur around Bootjack, Memana and Blue Rocks, and many of the well developed profiles in Soil Associations mapped by Dimmock (1957) were developed during the Pleistocene.

Recent deposits include:

(1) alluvial deposits of the present drainage,
(2) soils developing on late Quaternary dunes and ridges,
(3) coastal barriers enclosing east coast lagoons,
(4) beach accumulations including shell beds,
(5) lagoonal peat deposits,
(6) cave and dune bone deposits,
(7) miscellaneous deposits.

The first three types of deposit will be discussed in more detail when the geomorphological aspects of the authors' studies are presented and only the others will be considered further here.

Beach Shell Accumulations

These occur at a number of shore localities and include buried deposits. At Yellow Beach, Lady Barron, digging into the sandy beach 0.3 m. below the high tide level exposes a packed shell bed 15-23 cm. below the surface and extending to at least 0.6 m. in depth. The fauna (Table 4) is identical to that of the present shore here, and pieces of wood occur amongst the shells at about 0.4 m. depth. This wood gave a radiocarbon dating of 3,970±90 years B.P., suggesting that the deposit possibly formed by a sea retreating from a Post-Glacial higher level (E. D. Gill, pers. comm.).

Lagoonal Peat Deposits

Descriptions and approximate analysis and oil determination of material from such a deposit near Badger Corner are given by Carey (1945), Blake (1947) and Nye (1969). Cane (1966), investigating alleged 'oil' occurrences in this area showed that it was plant degredation product derived from such peaty material and gave further chemical analyses. Peats associated with lagoonal soils of the Wingaroo Association on the east coast are described by Dimmock (1957, p. 31).

Cave and Dune Bone Deposits

Scattered and fragmented bones have been found in crevices and in floor deposits of a cave in Palana Limestone, W. of Ranga (grid 486N-935E). A collection (F. Henwood and L. L. Waterhouse, 1917; Scott and Lord, 1922) includes *Vombatus ursinus* (femur, fig. Scott, 1915) and *Arctocephalus tasmanicus* (proximal phalange, first digit right fore flipper, ident. R. M. Warneke, 1965:39:10) as well as bones (ident. N. A. Wakefield) of *Potorous tridactylus* (femora, 1965:39:4), *Wallabia rufogrisea* (femora and skull, 1965:39:3) and *Trichosurus vulpecula* (ulna fragments, 1965:39:5). More recent excavations and explorations in the cave yielded further marsupial bones of dasyurids, vombatids, perameliids, phalangerids, macropods and murids, as well as some lizard and bird bones (Hope, 1969). Most of the recovered species are still extant on the Island, but some are now found only on the Tasmanian mainland, and two species, *Aepyprymnus rufescens* and *Pseudomys* cf. *novaehollandiae*, no longer live in South eastern Australia. The two topmost layers of the bone deposits in the cave floor gave Carbon 14 dates of 8,110±340 and 8,200±120 years B.P. respectively, and Hope suggests that the deposit may partly represent an old lair of the Tasmanian Devil *Sarcophilus harrisi*.

A sub-fossil bone deposit was exposed in a large sand blow in Lughrata Sand at Palana and included remains of tachyglossids, dasyurids, perameliids, phalangerids, vombatids, macropods, murids, birds and lizards (Hope, 1969). Almost all the species represented in the deposit are present on Flinders Island today, but *Isodon obesulus* now exists in Bass Strait only on West Sisters Island and *Sarcophilius harrisi* is now extant only on the Tasmanian mainland. Macropod and vombatid bones were also exposed in sand blows at Killiecrankie and Trousers Point.

Miscellaneous

Emu egg shell fragments were recovered near Emita, 6.5 Km. inland at about 180 m. elevation (coll. F. Jackson, 1917; 1965:39:6). This appears to be the first record of the emu on the Furneaux group, but the distribution data of this bird makes it uncertain that the Flinders Island fragments are truly local (Hope, 1969, p. 232).

An Australite, found in an abandoned tin mine near Killiecrankie Bay (Tasm. Mus. Colln. Y132, pres. J. Dunn, 1962) is lens shaped, 12x9x5 mm. in size (S.G. 2.45) and shows numerous fine ridges radiating from the centre of one surface. This presumably belongs to the tektite shower over Australia dated stratigraphically as late Pleistocene or early Holocene, possibly between 7,380±250 and 4,830±250 years B.P. (Gill, 1965). However, recent K-Ar isotopic dating of Australites (McDougall and Lovering, 1969) indicates an age of formation possibly as old as 0.86±0.06 m.y., with atmospheric flight shortly after. This enigma between physical and stratigraphic dating still requires reconciliation.

SUMMARY AND CAINOZOIC HISTORY

TERTIARY

Uplift

Vertical faulting and tilting in the late Mesozoic or Palaeocene epeiorogeny of Tasmania and Bass Strait (Spry and Banks, 1962; Jennings, 1959a; Richards and Hopkins, 1969) presumably elevated the Flinders Island Palaeozoic basement highlands. The topography suggests S.W. facing fault scarp blocks, downtilted to the N.E., and the main movements were probably along N.W. to N.W.N. trends with N.E. to E. cross-faulting and associated jointing. The prominent N.W. trend in joint patterns in the granite basement (Hughes, 1959a; aerial photograph inspection) probably belongs here as most of the late-stage basic dykes of the granite basement trend N.E.

Erosion

The Lower Tertiary history of Flinders Island is scantily recorded. It was probably one of terrestrial and coastal erosion of the uplifted fault blocks, with accumulation of detritus and organic matter around their flanks as non-marine and/or estuarine alluvial deposits. Such deposits are preserved under basalt E. of Whitemark, and on Cape Barren Island are dated as Upper Oligocene/Lower Miocene.

Volcanism

Volcanism, possibly commencing in the Lower or Mid-Tertiary, appears related to the Tertiary fracturing and the basement structure, with rough alignment of centres from Badger Corner, Ranga, Whitemark, Mt Leventhorpe, Parrys Bay and Lughrata to Tanners Bay-Palana areas. Olivine-nephelinites erupted in the central part of the Island and alkali olivine-basalts to the north and south, sometimes bringing up peridotite and country rock fragments. A tuff-shower at Samphire River overwhelmed swampy melaleuca vegetation there producing silicified logs, and tuff at Whitemark may have exploded from aqueous eruption.

Marine Deposition

Marine transgression on Flinders Island probably took place during early Miocene time, in accord with such deposits on Tasmania, Victoria and Cape Barren Island (Ludbrook, 1967; Richards and Hopkins, 1969), with the record removed or obscured by later erosion or deposition. Regression of the Miocene high sea in Upper Miocene-Lower Pliocene time, from evidence from Gippsland Basin and Bass Strait shores (Bowler, 1963; Bock and Glenie, 1965; Taylor, 1966; Sutherland and Corbett, 1967), presumably affected Flinders Island and accords with fossils washing ashore from inferred off-shore Kalimnan beds and with derived Upper Miocene-Lower Pliocene foraminifera in the aeolian Palana Limestone.

Later Pliocene marine transgression on Flinders Island is indicated by the post-Kalimnan Cameron Inlet Formation at elevations above present sea-level. These suggest a shore line fringing the eastern and northern flanks of the Darling Range and extending north through Wingaroo. Withdrawal of this sea by late Tertiary time is indicated by erosion and deposition of Pliocene remanié shells in overlying transgressive Lower Pleistocene marine deposits of the Memana Formation.

QUATERNARY

Climatic changes related to the Pleistocene Glacial had important effects on Flinders Island. Conditions became favourable for extensive dune building, and sea-level fluctuations left their imprint through variations in marine and terrestrial erosion and deposition giving stranded shorelines, dune movements and lagoonal developments.

Dune Building

Dune building on the west coast was predominantly calcareous. Vast areas of Tertiary calcarenites and marls were probably exposed on withdrawal of the initial Glacial sea, providing an abundant calcareous source. Siliceous sediment may have been largely removed from the area by predominantly east flowing currents in Bass Strait (typical of present winter flow, Vaux and Olsen, 1961), and siliceous dunes only formed in localised areas where rivers acted as siliceous sources. In contrast, dune building on the east coast was predominantly siliceous. A contributing source of siliceous sediments appears to have been the straits bounding the Island acting in similar fashion to rivers, and predominant long term drifts operating along the Tasmanian coast also tend to concentrate siliceous sediment on the N.E. corner of Tasmania (Davies, 1965). This sediment, with material eroded from Flinders Island over long periods, was probably transported by the easterly currents to deposit on the eastern coastal shelf as an abundant siliceous source.

The dune building was apparently a repeating pattern of formation of coastal dunes during relative still-stands in sea-level fluctuations, parabolic re-orientations of dunes during stormy periods, and erosion and drowning of dunes by marine transgressions during Interglacials and Interstadials. Orientations in the parabolic dune systems reflect the influence of the prevailing westerly winds, which have obviously operated over much of the Quaternary and would be particularly severe as the westerly wind belts moved northwards during Glacials. East-west orientations predominate on the west facing parabolic dune series of the west coast and inland, and also occur in east coast dune series, which however show more marked E.N.E./S.W.S. and N.W.N./S.E.S. orientations.

The older dune series of the Island became increasingly consolidated with time and developed mature soil profiles (Dimmock, 1957). Calcareous dunes, as now forming Palana Limestone, became subject to secondary cementation with formation of calcareous 'B' soil horizons. Leaching of top parts of dunes probably gave 'A' horizons of siliceous residue which possibly blew off exposing the underlying limestone and may have contributed in part to sand ridge deposits such as Liapota Sand and Altmoor Sand. Cave development was probably initiated fairly early in the consolidation of the calcareous dunes, with some development of linear caves occupied by streams. Rapid erosion by the streams resulted in sink holes, gorges and stranded caves as found west of Ranga (older than 8,000 years B.P.).

Consolidated dunes with lower calcareous content (west coast, e.g. Trousers Point aeolianite) and typically siliceous content (east coast, e.g. Petibela Sand) developed during the Upper Pleistocene. Unconsolidated parabolic dunes (e.g. Lughrata Sand and Nala Sand dunes) probably originated as beach ridges or foredunes developing continuously from the Würm Glacial. The parabolic movements were probably initiated during stormy conditions in the Würm, continuing into the Post-Glacial period, and truncation of the parabolic ridges took place with establishment of a Post-Glacial shore line. A coastal beach ridge system (Lackrana Sand) developed, continuing through to the present and punctuated in places with minor parabolic movements. The evidence of the barrier at Arthur River, at least, suggests a still-stand or a relative slowing down of the Post-Glacial sea-rise, before a rapid rise to a 0.6-1.5 m. (MHWS) level flooding the barrier, possibly about the Post-Glacial Thermal Maximum (Gill, 1955).

Lagoon Formation

Extensive lagoon development, particularly on the east coast, has been associated with dune formation on the Island, following impounding of drainage by coastal barriers and by parabolic movements. Traces of old lagoons formed during the Pleistocene and early Holocene are found in inland areas and freshwater limestones were deposited in some of these.

During the early Holocene, probably in a period of increased rainfall, small lagoons impounded by para-

bolic dunes increased in size and coalesced to form extensive lagoonal areas of Nelson Lagoon type. Further lagoons formed meanwhile in swales of parabolic dunes. Many of these became reduced in size, probably during a period of reduced rainfall, and lunettes developed. With the building of the present beach ridge coastal barrier, apparently following establishment of the Post-Glacial sea, extensive coastal lagoons and inlets have formed. Encroachment of the lunette at Hogans Lagoon onto the oldest beach ridges suggests that lunette formation and the associated climatic period were probably later than the Post-Glacial sea-rise.

Marine Fluctuations

Sea-level fluctuations associated mainly with Pleistocene Glacial fluctuations have left traces of old shore lines on Flinders Island. Erosional and/or depositional features have been observed associated with old shore lines at 57-72 m., 27-33 m., 15-18 m., 4.5-6 m. and 0.6-1.5 m. above MHWS. Erosional features are represented by benches cut in granite, dune limestones and other sediments, in places forming extensive coastal flats, and in the case of the 0.6-1.5 m. level by truncation of parabolic dune series. Depositional features include the Memana Formation (a shallow water marine horizon occupying a Lower Pleistocene embayment in the North Patriarch area), Marshall Bay Coquina (probably a beach deposit associated with the 15 m. level), East River Coquina (bay floor and sea-channel deposits, some with remanié material derived from underlying horizons by penecontemporaneous erosion, probably related to the 4.5 m. level) and Petrification Bay Coquina (a shallow bay deposit associated with the 0.6 m. level). Angular grits and associated sediments (e.g. Loccota Grit) probably represent detrital accumulations resulting from heightened erosion associated with marine withdrawals, as in the Würm. Well worn grits (e.g. Opossum Boat Harbour Grit) probably represent extensive reworking of such deposits during marine advances, as in the Riss/Würm Interglacial.

The 0.6-1.5 m. level includes a Post-Glacial level and possibly some late Pleistocene levels, as dated elsewhere (Gill, 1970). Dating at Lady Barron beach suggests that the sea was near this level at least 4,000 years ago. The 4.5 m. and 15 m. levels can probably be assigned to the Riss/Würm, but higher levels are probably pre-Riss/Würm and the 57-72 m. level may even represent the Mid-Miocene high sea. Many aspects of dune building and evidence of sea-level fluctuations from the Upper Cainozoic on Flinders Island parallel developmental histories of the Bass Strait region on King Island (Jennings, 1959b), the Tasmanian north coast (Edwards, 1941; Sutherland, 1971; Gill, 1970) and the Victorian coast (Jennings, and Mabutt, 1967; Jenkin, 1968).

Faunal Fluctuations

Sea-level and associated climatic fluctuations on Flinders Island during the Cainozoic would influence terrestrial faunal movements and at times isolate populations. The Island undoubtedly formed part of land bridges that connected Tasmania and the Australian mainland during Pleistocene Glacial marine withdrawals, when sea-level along Australian shores may have fallen 135 m. and possibly as much as 180-210 m. in depth (Packham, *et. al.* 1969; Gill, 1970; Jongsma, 1970).

Summaries of references to the known present fauna of the Island are given by Green (1969) and Hope (1969) and presumably endemic species are known from the Ranga cave (Green, 1963; Richards, 1967, 1970). Sub-fossil remains of *Aepyprymnus rufescens, Pseudomys* cf. *novaehollandiae, Sarcophilus harrisi* and the emu (?) represent animals no longer living on the Island, and Hope (1969) discusses possible migration and isolation patterns of some vertebrate distributions across Bass Strait.

Of interest here is the Tasmanian Aborigine, an isolated race when discovered by Europeans and occupants of Tasmania at least 9,000 years ago. Mainland Australian excavations yield similar stone implements in lower levels to Tasmanian types, suggesting a mainland origin for the race and use of the Furneaux chain as a land bridge, probably between 16,000 and 11,000 years ago (Jones, 1968). Some possible evidence of prehistoric Aboriginal occupation of Flinders Island is very meagre (W. F. Ellis, pers. comm.). Rare Aboriginal artefacts from Cape Barren Island include some flaked stone atypical of the Island and possibly transported by visitor (Rhys Jones and R. A. Littlewood, colln.). However, coastal Aboriginal camps on the old Furneaux landbridge would be now submerged under Bass Strait (Jones, 1968).

At present, the Flinders Island area experiences occasional earth tremors, being one of the seismically strongest regions of the generally quiet Tasmanian block. A swarm of tremors in N.E. Tasmania in 1883-1886 probably originated from off-shore epicentres (Shortt, 1885, 1886; Biggs, 1886). Epicentres plotted since 1929 (magnitude, m4.0-5.7) fall across the middle of the Island and may be related to cross-structures on a westerly striking seismic zone extending through the Island across Bass Strait from Longitude 156° to 144° (Doyle, Everingham and Sutton, 1968).

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APPENDIX I

Petrological Descriptions, Flinders Island Cainozoic Volcanic Rocks

T.S. numbers refer to catalogued thin sections in the Tasmanian Museum collection.

Samphire River—Adelaide Bay—Chew Tobacco Creek (T.S. 1338, 1342, 1344, 1482).

Corroded glomeroporphyritic olivine (10-15%, 3 mm. max., $2V_z \sim 93\text{-}97° \pm 3°$) is set in an intergranular groundmass of plagioclase laths (35-45%, 1.4 mm. max., mostly <0.5 mm., zoned from about Ab 44-50), pale pinkish augite (30-35%, 0.4 mm. max., av. 0.1 mm.) olivine (5%) and opaque iron oxide (5%, titano-magnetite or ilmenite), minor apatite and interstitial zoned sodic plagioclase. In dense samples the olivine is largely unaltered, iron oxides tend to form squarish grains, and interstitial patches of carbonate (up to 10%) and serpentinitic material may be prominent. In more amygdaloidal varieties olivine is rimmed by green opal or is largely altered to serpentine, 'bowlingite' and carbonate, iron oxide tends to form elongate blades, and amygdaloidal fillings include calcite, ferroan carbonate, clay, opal and chalcedony. Rare accidental quartz and quartz aggregate inclusions show thin reaction coronas of clinopyroxene needles.

N. Ranga-E. Whitemark (T.S. 1139, 1141; Analysis 1, Table 2).

Glomerophenocrysts of corroded olivine (10-15%, 1.4 mm. max., $2V_z \sim 95\text{-}100°$) and euhedral oscillatory-zoned titaniferous augite (5-10%, 1.5 mm. max., $2V_z \sim 62\text{-}48° \pm 2°$) are held in subophitic to intergranular and poikilitic groundmass of plagioclase laths (20-30%, 0.9 mm. max., zoned from about Ab 44-50), titaniferous augite (20-30%, mostly 0.05-2 mm.), sporadic iron oxide (to 0.7 mm.), apatite and rare olivine, with interstitial zoned sodic plagioclase (to 15%), minor colourless glass dusted with iron oxide and amygdaloidal carbonate.

Whitemark (Palagonite Tuff; Petrological Records, Tasm. Mines Ser. No. 58-23).

'Dark coloured rock composed of black porous fragments cemented together by carbonate of lime.

In thin sections the black fragments appear as a brown glass and a green zeolite. The glass contains many pores some of which are filled with zeolite spherulites and others with calcite. Some fragments consist entirely of masses of zeolite spherulites. The refractive index of the glass varies, being in some parts lower than Canada balsam, in others, higher. Plagioclase and olivine occur as relic minerals from the original glass'.

E. Leventhorpe (T.S. 1483-1484)

Corroded olivine phenocrysts and grains (15-20%, 2.5 mm. max., $2V_z \sim 93\text{-}100°$) are dispersed in an intergranular to poikilitic groundmass of plagioclase laths (35-40%, 0.8 mm. max., zoned from about Ab 44-50), colourless augite (30%, 0.4 mm. max.), sporadic iron oxide (to 0.5 mm.), minor serpentinite and chlorite, small apatite needles, and interstitial and amygdaloidal zeolite (5-10%, mainly phillipsite?).

Tanners Bay-Boat Harbour-Palana (T.S. 1142, 1296-1298, 1341, 1343).

Glomeroporphyritic corroded olivine (5-20%, 3 mm. max., $2V_z \sim 90\text{-}98°$) is contained in an intergranular to pilotaxitic groundmass of plagioclase laths (35-50%, 0.4 mm. max., zoned from about Ab 44-50), pinkish augite (20%, 0.3 mm. max.,), squarish iron oxide grains (5-10%, 0.2 mm. max.,), granular olivine, apatite needles and interstitial zoned sodic plagioclase. Amygdales may contain greenish to yellowish colloform opal, radiating calcite or ferroan carbonate. Some rocks contain rare microphenocrysts of titaniferous augite (1 mm. max., sometimes with corroded riddled cores) and aggregates of prismatic clinopyroxene, sometimes in reaction coronas around fused or partially fused quartz and rare feldspar xenocrysts.

Parrys Bay (T.S. 1300, 1340, 1485-1488).

Corroded olivine phenocrysts and rarer xenocrysts (10-20%, 3 mm. max., $2V_z \sim 88\text{-}100°$) grade into a groundmass of titanaugite (30-50%, 0.6 mm. max.), squarish to irregular iron oxide grains (7%, mostly <0.2 mm.) and coarse to needle-like apatite prisms (3%, 0.6 mm. max.), with a poikilitic or hyalopilitic mesotasis (10-30%) containing variable proportions of idiomorphic to allotriomorphic potassic nepheline (0.6 mm. max.), colourless to brownish glass, some alkali feldspar, and interstitial and amygdaloidal zeolites, including stilbite, natrolite and analcime.

N. Lughrata (T.S. 1301, 1345, 1592, Analysis 2, Table 2).

Corroded olivine phenocrysts and peridotitic xenocrysts and xenoliths form 35% of the rock, in a fine grained groundmass of augite (mostly <0.2 mm.), granular olivine, squarish iron oxide grains and apatite needles in a feldspathoidal base (20%) containing potassic nepheline, colourless glass and zeolites (including analcime and natrolite) in patches up to 0.3 mm. across.

The peridotitic xenoliths (mostly <2 cm.) consist predominantly of olivine, associated withh orthopyroxene, clinopyroxene and spinel in allotriomorphic consertal to granular inclusion textures. Xenocrysts (mostly <4 mm.) derived from these xenoliths are commonly distinguished by exsolution, resorption and strain phenomena and by reaction coronas and overgrowths of the host groundmass minerals. Magnesian olivine ($2V_z \sim 88\text{-}97°$; MgO 46.6, FeO 11.1) may show strain polarisation and translation lamellae; aluminous enstatite ($2V_z \sim 76\text{-}84°$; SiO_2 53.4, MgO 33.7, 'FeO' 5.8, Al_2O_3 5.0) may show lamellar or granular exsolution of clinopyroxene, spongy resorption or symplectic resorption intergrowths, and overgrowths of augite or coronas of olivine and iron oxide; sodic aluminous endiopside ($2V_z \sim 70\text{-}66°$; SiO_2 51.7, CaO 19.3, MgO 16.5, Al_2O_3 7.7, 'FeO' 3.0, Na_2O 2.2) may show corrosion riddling and overgrowths of zoned groundmass augite ($2V_z \sim 53\text{-}41°$; SiO_2 49.8, CaO 23.3, MgO 14.3, 'FeO' 7.4, Al_2O_3 4.9, TiO_2 1.7) becoming coloured and titaniferous towards the rims; and olive to reddish brown chrome (?) spinel (Al_2O_3 54.3, MgO 21.1, 'FeO' 10.3) may show opaque reaction rims of chrome (?) iron oxide (preliminary electron microprobe analyses, oxide percentages, per R. Varne).

REFERENCES

BIGGS, A. B., 1886: Tasmanian Earth Tremors. *Proc. Roy. Soc. Tasm.* for 1885: 325-34.

BLAKE, F., 1935: Preliminary Report on Furneaux Group of Islands. *Unpubl. Rep. Dep. Mines Tasm.*

BLAKE, F., 1947: The Furneaux Group of Islands. *Unpubl. Rep. Dep. Mines Tasm.* (1947): 52-82.

BOCK, P. E., and GLENIE, R. C., 1965: Late Cretaceous and Tertiary Depositional Cycles in South-Western Victoria. *Proc. Roy. Soc. Vict.*, **79:** 153-63.

BOWLER, J. M., 1963: Tertiary Stratigraphy and Sedimentation in the Geelong-Maude area, Victoria. *Proc. Roy. Soc. Vict.* **76:** 69-137.

CANE, R. F., 1966: 'Oil' on Flinders Island-Bass Strait. *Proc. Roy. Soc. Tasm.* **100:** 153-5.

CAREY, S. W., 1945: Interim report on the possibility of petroleum on Flinders Island. *Unpubl. Rep. Dep. Mines Tasm.* (1945): 153-5.

CAREY, S. W., 1953: The Geological Structure of Tasmania in relation to Mineralisation. *5th Emp. Min. Met. Congr.* **1:** 1108-1128.

CHAPMAN, F., and PRITCHARD, G. B., 1904: Fossil Fish Remains from the Tertiaries of Australia 1. *Proc. Roy. Soc. Vict.* **17:** 267-97.

CHAPMAN, F., and PRITCHARD, G. B., 1907: Ibid. 2. *Proc. Roy. Soc. Vict.* **20:** 59-75.

CRESPIN, I., 1945a: Report on Six Samples of Limestone from Localities in Flinders Island, Tasmania. *Aust. Dep. Supp. & Shipp. Min. Res. Surv. Br. Rep.* (1945-71).

CRESPIN, I., 1945b: Middle Miocene Limestone from Cape Barren Island, Furneaux Group, Bass Strait. *Proc. Roy. Soc. Tasm.* for 1944: 13-14.

DARRAGH, T. A., 1965: Revision of the Species of Eucrassatella and Spissatella in the Tertiary of Victoria and Tasmania. *Proc. Roy. Soc. Vict.* **78:** 95-114.

DARRAGH, T. A., and KENDRICK, G. W., 1970: The Fossil *Zenatiopsis ultima* sp. nov., terminal species of the *Zenatiopsis* lineage (Bivalvia; Mactridae). *Proc. Roy. Soc. Vict., in press.*

DAVIES, J. L., 1957: Sea Level Changes and Shore Line Development in South-Eastern Tasmania. *Proc. Roy. Soc. Tasm.* **93:** 89-98.

DAVIES, J. L., 1965: Landforms. *Atlas of Tasmania.* Lands and Surveys Dept. Hobart: 19-22.

DIMMOCK, G. M., 1957: Soils of Flinders Island (*CSIRO Div. Soils Rep.* 85/56. Map). Soils and Land Use Series. **23:** 1-68.

DORMAN, F. H., 1966: Australian Tertiary Palaeotemperatures. *J. Geol.* **74:** 49-61.

DOYLE, H. A., EVERINGHAM, I. B., and SUTTON, D. J., 1968: Seismicity of the Australian Continent. *J. Geol. Soc. Aust.* **15:** 295-312.

EDWARDS, A. B., 1941: The North-West Coast of Tasmania. *Proc. Roy. Soc. Vict.* **53:** 233-60.

EVERARD, G., 1950: The Limestone Resources, General Geology and Geomorphology of Flinders Island. *Unpubl. Rep. Dep. Mines Tasm.*

FLINDERS, MATTHEW, 1814: A Voyage to Terra Australis. Vol. 1. London.

GILL, E. D., 1955: The Australian Arid Period. *Aust. J. Sci.* **17:** 204-6.

GILL, E. D., 1962: Past and Present Distribution in Australia of the Gastropod Tylospira. *J. Malac. Soc. Aust.* **6:** 33-7.

GILL, E. D., 1964: Rocks contiguous with the Basaltic Cuirass of Western Australia. *Proc. Roy. Soc. Vict.* **77:** 331-55.

GILL, E. D., 1965: Radio-Carbon Dating of Australite Occurrences, Microliths, Fossil Grasstree and Human Podsol Structures. *Aust. J. Sci.* **27:** 300-1.

GILL, E. D., 1970: Current Quaternary Shoreline Research in Australasia. *Aust. J. Sci.* **32:** 426-30.

GILL, E. D. and BANKS, M. R., 1956: Cainozoic History of Mowbray Swamp and Other Areas of North-Western Tasmania. *Rec. Q. Vict. Mus.* **6.**

GOULD, C., 1872: The Islands in Bass Straits. *Proc. Roy. Soc. Tasm.* for 1871: 57-67.

GREEN, A. J. A., 1963: A New Species of Echinodillo (Isopoda, Oniscoidea, Armadillidae) from Flinders Island, Tasmania. *Proc. Roy. Soc. Tasm.* **97,** pp. 77-80.

GREEN, R. H., 1969: The Birds of Flinders Island. *Rec. Q. Vict. Mus.* **34.**

HARRIS, W. K., 1965: Palynological Examination of Samples from North East Tasmania, Cape Barren, and Flinders Island. *Dep. Min. South Aust. Palyn. Rept* 6/65. Typewritten Report Bk 60/115.

HOPE, J. H., 1969: Biogeography of the Mammals on the Islands of Bass Strait with an Account of Variation in the Genus *Potorous. Ph.D. Thesis.* Monash University.

HUGHES, T. D., 1957: The Limestones of Tasmania. *Tasm. Dep. Min. Res.* **10.**

HUGHES, T. D., 1959a: Alleged Uranium Discovery at Flinders Island. *Tech. Rep. Dep. Min. Tasm.* **3:** 32-3.

HUGHES, T. D., 1959b: Water Supply for Hospital, Whitemark, Flinders Island. *Tech. Rep. Dep. Min. Tasm.* **3:** 112-15.

JACK, R., 1966: Flinders Island Tin Deposits. *Tech. Rep. Dep. Min. Tasm.* **10:** 49-50.

JENKIN, J. J., 1968: The Geomorphology and Upper Cainozoic Geology of South East Gippsland, Victoria. *Geol. Surv. Vict. Mem.* **27.**

JENNINGS, J. N., 1959a: The Submarine Topography of Bass Strait. *Proc. Roy. Soc. Vict.* **71:** 49-72.

JENNINGS, J. N., 1959b: The Coastal Geomorphology of King Island, Bass Strait, in Relation to Changes in the Relative Levels of Land and Sea. *Rec. Q. Vict. Mus.* **11.**

JENNINGS, J. N., and MABBUTT, J. A. (Eds), 1967: *Landform Studies from Australia and New Guinea.* A.N.U. Press, Canberra.

JOHNSTON, R. M., 1879: Notes on Certain Tertiary and Post-Tertiary Deposits On Flinders, Barren, Badger and Other Islands in Bass' Straits. *Proc. Roy. Soc. Tasm.* for 1878: 41-50.

JOHNSTON, R. M., 1887: Reference List of the Tertiary Fossils of Tasmania. *Proc. Roy. Soc. Tasm.* for 1886, pp. 124-40.

JONES, RHYS, 1968: The Geographical Background to the Arrival of Man in Australia and Tasmania. *Arch. and Phys. Anthr. in Oceania.* **3:** 186-215.

JONGSMA, D., 1970: Eustatic Sea Level Changes in The Arafura Sea. *Nature.* **5267:** 150-1.

KEID, H. W. G., 1949: Mineral Deposits of Flinders and Cape Barren Islands. *Unpubl. Rep. Dep. Min. Tasm.*

KERSHAW, R. C., 1958: Tasmanian Intertidal Mollusca. *J. Malac. Soc. Aust.* 1: **2:** 58-100.

KERSHAW, R. C., and SUTHERLAND, F. L., in press: Quaternary Geomorphology of Flinders Island, Bass Strait. *Rec. Q. Vict. Mus.*

LUDBROOK, N. H., 1965: Palaeontological Reports and Accompanying Notes on Samples F33/65 and F34/65 from Flinders Island, Tasmania. Typewritten Report 1094/64. *Dep. Min. South Aust.*

LUDBROOK, N. H., 1967: Correlation of Tertiary Rocks of the Australasian Region. From Tertiary Correlations and Climatic Changes in the Pacific. February, 1967.

LUDBROOK, N. H., 1969: The Genus Miltha (Mollusca, Bivalva) in the Australian Cainozoic. *Trans. R. Soc. S. Aust.* **93:** 55-63.

MCDOUGALL, I., and LEGGO, P. J., 1965: Isotopic Age Determinations on Granite Rocks from Tasmania. *J. Geol. Soc. Aust.* **12:** 295-332.

MCDOUGALL, I., and LOVERING, J. F., 1969: Apparent K-Ar dates on cores and excess Ar in flanges of Australites. *Geochim-Cosmochim-Acta.* **33:** 1057-70.

MARWICK, J., 1960: A New Pliocene Struthiolaria *(Gastropoda)* from Flinders Island, Tasmania. *Proc. Roy. Soc. Vict.* **72:** 41-4.

MAY, W. L., 1958: An Illustrated Index of Tasmanian Shells (revised by J. Hope Macpherson). Tasm. Gov't Printer.

NYE, P. B., 1931: Underground Water at 'Wingaroo', 5 Mile Lagoon District, Flinders Island. *Unpubl. Rep. Dep. Mines Tasm.*

NYE, P. B., 1969: Some Occurrences of Peat or Semi-peat in Tasmania. *Tech. Rep. Dep. Min. Tasm.* **13:** 34-6.

PACKHAM, G. H. (ed.), 1969: The Geology of New South Wales. *J. Geol. Soc. Aust.* **16,** 1.

PETTERD, W. F., 1911: The Minerals of Tasmania. *Proc. Roy. Soc. Tasm.* for 1910: 1-222.

PRYOR, R. J., 1967: Soil Type and Land Use, Flinders Island. *Proc. Roy. Soc. Tasm.* **101:** 261-6.

QUILTY, P. G., 1965: The Age of Tasmanian Marine Tertiary Rocks. *Aust. J. Sci.* **29:** 143-4.

RICHARDS, A. O., 1967: The Raphidophoridae (Orthoptera) of Australia, Part 5. The Raphidophoridae of Flinders Island. *Proc. Linn. Soc. N.S.W.* **92,** 3: 273-8.

RICHARDS, A. O., 1970: Ibid. Part 8. Two new species of *Parvotettix* Richards. *Pacif. Ins.* **12, 1:** 1-8.

RICHARDS, K. A., and HOPKINS, B. M., 1969: Exploration in the Gippsland, Bass and Otway Basins. E.C.A.F.E., Canberra.

SCOTT, H. H., 1915: Some Notes on the Humeri of Wombats, Q. *Vict. Mus. Broch.* **5.**

SCOTT, H. H., and LORD, C. E., 1922: The Cave Deposits at Mole Creek. *Proc. Roy. Soc. Tasm.* for 1921: 6-8.

SHORTT, J., 1885: Summary of Observations on Earthquake Phenomena made in Tasmania during 1883 and 1884. *Proc. Roy. Soc. Tasm.* for 1884: 263-70.

SHORTT, J., 1886: Earthquake Phenomena in Tasmania. Ibid for 1885: 400-02.

SINGLETON, F. A., and WOODS, N. H., 1934: On the Occurrence of the Pelecypod Genus Miltha in the Australian Tertiary. *Proc. Roy. Soc. Vict.* **46:** 207.

SINGLETON, O. P., and JOYCE, E. B., 1969: Cainozoic Volcanicity in Victoria. *Spec. Publs. Geol. Soc. Aust.* **2:** 145-54.

SPRY, A. H., and BANKS, M. R., (Ed.), 1962: 'The Geology of Tasmania.' *J. Geol. Soc. Aust.* **9,** 2.

STRZELECKI, Count P. E., 1845: Physical Description of New South Wales and Van Diemen's Land, L, B, G & L. London.

SUTHERLAND, F. L., 1969: A Review of the Tasmanian Cainozoic Volcanic Province. *Spec. Publs. Geol. Soc. Aust.* **2:** 133-44.

SUTHERLAND, F. L., 1971: The Geology and Petrology of the Tertiary Volcanic Rocks of the Tamar Trough, Northern Tasmania. *Rec.* Q. *Vict. Mus.,* 36.

SUTHERLAND, F. L., and CORBETT, K. D., 1967: The Tertiary Volcanic Rocks of Far North-West Tasmania. *Proc. Roy. Soc. Tasm.* **101:** 71-90.

TASMANIAN DEPARTMENT OF MINES, 1970: Catalogue of the Minerals of Tasmania. *Geol. Surv. Rec.* 9.

TAYLOR, D. J., 1966: Esso Gippsland Shelf N°-1; The Mid-Tertiary Foraminiferal Sequence. Appendix 2. *Bur. Min. Res. Geol. Geophys. Aust. Petroleum Search Subs. Acts Publ.* **76.**

TURNER, E., 1970: A Systematic List of Molluscs Dredged by the Japanese Research Ship *Umitaka Maru* in January, 1968. *Tasm. Fisheries Research,* **4, 2:** 1-18.

VAUX. D., and OLSEN, A. M., 1961: The Use of Drift Bottles in Fisheries Research. *Aust. Fisheries Newsletter.* **20:** 17-20.

WILKINS, R. W. T., 1962a: In Cainozoic Marine Succession in 'The Geology of Tasmania'. *J. Geol. Soc. Aust.* **9,** 2:235.

WILKINS, R. W. T., 1962b: Miltha in the South-Eastern Australian Tertiary. *J. Malac. Soc. Aust.* **6:** 43-9.

ADDENDUM

Silicified plant material recently recovered from low tide level at Petrifaction Bay (Tasm. Mus. Colln. Z1591, pers. Mrs A. W. McPhie and Mr R. Hewer) contains cones, twigs and needles, probably of casuarina (Dr J. A. Townrow, pers. comm.). It is presumably sub-basaltic in origin which suggests an age probably not exceeding early Pliocene for the basalt there. If the supposition is held that the basalt blocked the post-Kalimnan/pre-Maretimo marine transgression then this would imply a Lower Pliocene (Kalimnan) age for this eruption.

PLATE 1.

Fig. 1.—Pliocene coquinoid limestone (Cameron Inlet Formation), exposed in quarry, foot of The Dutchman (type locality of Wilkins 1962 Dutchman Coquina), looking North, 1957 photograph.

Fig. 2.—Nelson Lagoon Drain section, ½ mile N. of East River, looking north, 1957 photograph. Pliocene shelly marl (base of drain) and shelly sands of the Cameron Inlet Formation are disconformably overlain by Upper Pleistocene (?) East River Coquina containing numerous remanié *Cucul'aea* at its base.

Fig. 3—Lower Pleistocene (?) coquinoid calcrete (Memana Formation), from outcrop E. end N° 11 Road, Furneaux Estate.

Fig. 4.—Cliff of Opossum Boat Harbour Grit (Upper Pleistocene?), type locality. Note erosion at cliff base, just above HWM and also at higher level below cliff top.

Fig. 5.—Aeolianite (younger Palana Limestone member), S. of Trousers Point, looking north. The aeolianite shows marked aeolian bedding, rests on granite and its upper surface is coincident with the 4.5 m. level above MHWS.

Fig. 6.—Type locality of Petrification Bay Coquina (Holocene?), which forms the terrace level just above high tide mark, looking north-east. Note basalt boulders on shore.

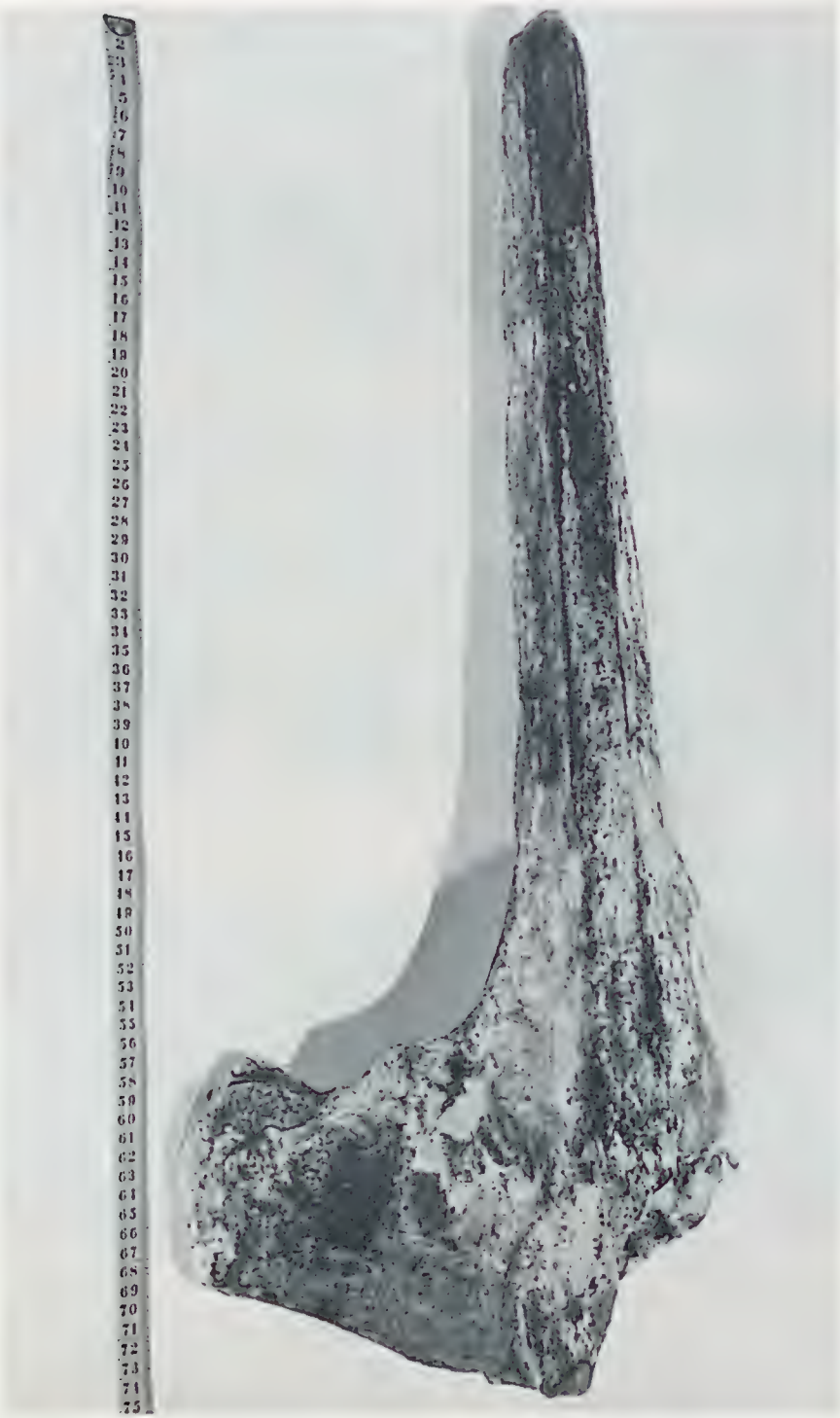

Plate 2.—Dorsal view, skull of new Pliocene whale, *Ziphius* sp., drain excavation, Memana Flinders Island (Photograph, per J. W. Warren). The scale is graduated in cms.

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GLACIATION OF THE MT LA PEROUSE AREA

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ABSTRACT

Glacial ice has been dominant in sculpturing the landscape of the Mt La Perouse area. Glacial erosional features, moraines and periglacial and nivational deposits indicated that the geomorphology of the area can be accounted for by one period of glaciation accompanied by periglaciation and nivation.

INTRODUCTION

Mt La Perouse is situated fifty miles southwest of Hobart. Access to the area can be gained by an eight to ten mile walk from a point on a Forestry Department road two miles from the township of Lune River.

The accompanying map (Fig. 1) like most maps of other glaciated areas of Tasmania, was produced by interpretation of erosional features and by the morphology rather than the stratigraphy of the associated deposits. This approach generally results in reasonably accurate interpretation of the final phases of glaciation and imprecise visualisation of the maximum extent of glacial ice.

PREVIOUS LITERATURE

Montgomery (1894) mentioned that the La Perouse area had been glaciated and Nicholls (1898) briefly discussed the geology of the area. Lewis (1925) made the first detailed observations on the glaciation which he showed on several clear sketch maps accompanied by fairly detailed descriptions emphasizing the evolution of the gross morphology. Lewis and Murray (1935) found evidence for separate phases of glaciation near the headwaters of the D'Entrecasteaux River. There they described a '. . . peculiar button grass covered . . . spur' which they interpreted as a moraine, the northern end of which they claim had been cut off and had had a later moraine deposited against it. However, Jennings and Banks (1958) disputed this and correctly described the feature as 'a series of structural benches carved from almost horizontal Permian rocks'. Derbyshire et. al (1965) have presented the glacial features on a map of scale 1 : 250000. The accompanying text did not contain detailed description but indicated that erosion by glacial ice only, and not erosion by periglacial or nivational processes, was figured.

Comparison of Fig. 1 with the map of Derbyshire et al. indicates marked similarity, difference probably being due to scale differences, except for the inclusion of the Lune Cirque (the feature at the headwaters of the Lune River) in Fig. 1. Lewis' maps do not compare as closely and some of the probable reasons for this follow the description below of the Lune Cirque.

Lune Cirque

The contour lines on Fig. 1 indicate the headwall of the Lune River to be 300 metres high and almost vertical. The aerial photograph Pl. 1, Fig. 1 shows the wall to be locally plucked along joints in the sedimentary rocks (approximately azimuth 60° and 150°). In the floor of the valley is a series of seven end moraines which are arcuate, independent of the present drainage from the southeast, and with the shorter dimension and curvature of the ridges indicating an origin at the northern end of Moores Bridge.

Immediately west of the headwall was (and still is) a large area for the accumulation of snow. During the Pleistocene the prevailing westerly winds should have ensured adequate snow supply to the cirque for the accumulation of névé and this factor, coupled with the depth of the valley should have maintained glacial ice in the valley at least during the height of glaciation. The headwall has a north-easterly to south-easterly aspect and Davies (in Jennings and Mabbutt, 1967, pp. 9-10) demonstrated the latter aspect to be most favourable for ice accumulation. This point is exemplified by the presence of snow in a nivation hollow at the headwall's western extremity through the summer to March 1969.

Under the conditions outlined above the ice body would have had a wedge-shaped east-west cross section (thinning to the east as shown in Fig. 1). Glacial ice eroded the steep headwall while periglacial activity was responsible for the more gently sloping, frost shattered, fluvially cut south-eastern margin. Periglacial meltwater from the north-western side of Moonlight Ridge flowed down the eastern margin of the ice and then down the Lune River.

The plucking of the headwall and presence of moraines suggests that Lewis was correct in describing the above feature as a cirque.

Periglaciation

Lewis' lack of appreciation of the effect of periglacial processes accounts for the major discrepancies between his maps and that presented here. For example, Lewis said the tributaries of the D'Entrecasteaux River (near 680480 and 700493, Fig. 1) were in glaciated valleys. Both these valleys are 'V' shaped and have no signs of till on the floors. The valley walls are covered by a superficial layer of boulders derived from ice wedging while run-off of periglacial meltwater has resulted in deep incision of the valleys. Fig. 2 shows the slope development caused by ice wedging on various types of sedimentary rocks. The more thickly-bedded sandstones and conglomerates are more resistant and have low angles of

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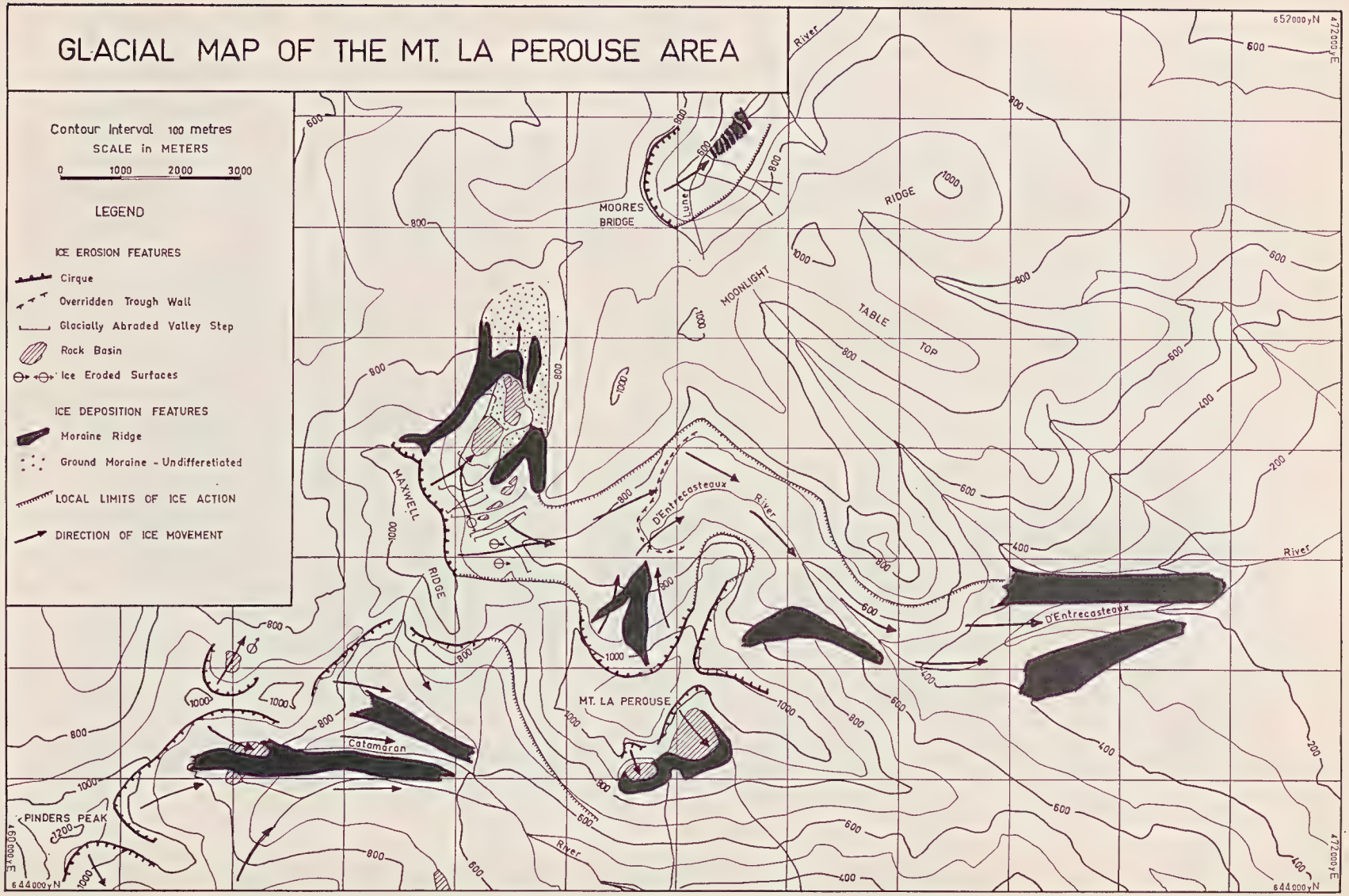

Fig. 1—Glacial Map of the Mt La Perouse Area.

slope development which inhibits erosion of the underlying more thinly-bedded, softer sandstones and mudstones. If in fact these valleys did contain glacial ice, there has been very rapid incision by fluvial processes since ice retreat and with hard, massive sandstones and conglomerates in abundance, this interpretation seems unlikely.

It may be demonstrated that the area down to about the 400 metre contour line experienced periglaciation at some stage, whether it be mostly peripheral to glacial ice at the height of glaciation or in glaciated areas during advance and retreat of ice. However, it is difficult to assess the difference between Pleistocene and Recent periglacial material. Groups of massive sandstone blocks up to four metres maximum diameter exhibit crude polygonal orientations on the ridge extending south-east from the summit of Mt La Perouse. This type of structure is considered to have resulted from Pleistocene periglacial activity as opposed to patterns developed with small siltstone fragments seen on the summit of Mt La Perouse (Pl. 1, Fig. 2) which are considered to be currently active.

Nivation

Five examples of erosion by movement of bodies of snow were observed. Four of these nivation depressions or hollows were situated in the uppermost part of the headwalls of past glaciers.

In all five examples, the writer found snow in the depression until March 1969. Lewis (1925, p. 39) noted the first recorded instance of erosion by nivation in Tasmania on a ledge just below and to the east of the summit of Mt La Perouse. He quoted evidence to show that the ledge commonly held a snow bank well into summer. Lewis said that 'This snow bank . . . moves a few yards down the gentle slope of the ledge. As it passes over the corrugations of the various beds of strata of soft coal measures (Lower Triassic red beds—Davidson, 1969) it has scratched the rock with the fragments it has torn from the adjacent cliff face . . . apparently the scratching is repeated each winter'. Scratches on the rock surfaces of the ledge may be seen now and small fragments of red bed and siltstone are embedded in the snow in the gap between the snow and the headwall of the depression. Fragments of the same rock type are also embedded in the base of the body of snow and there can be little doubt that the scratches were caused by the embedded rock fragments as the snow moved slowly across the ledge.

Small rock fragments, soil, plants and plant debris have been pulled away from the rock surface at the headwall of the other depressions by bodies of snow. These depressions are located on the northern face of Mt La Perouse about 50 metres below the summit (654461), on the eastern face of Maxwell Ridge just below the summit (637476), at the head of the Lune Cirque as mentioned previously (657505) and a very large one about 200 metres long and 50 metres wide on the south-eastern side of Hill 4, Moonlight Ridge (657485). All five occurrences represent favourable areas for snow accumulation. Apart from the example on Moonlight Ridge, all are in the upper head-walls of past cirques. The Moonlight Ridge nivational hollow is not in an ancient cirque because the area for snow accumulation was not sufficient to maintain a glacier even during the height of glaciation. However, the fact that this depression is the largest of the five depressions observed and is currently active suggests that it may be the only clear example in the La Perouse area, of a modern nivation hollow, the greater part of the hollow having formed as a result of Pleistocene nivational activity.

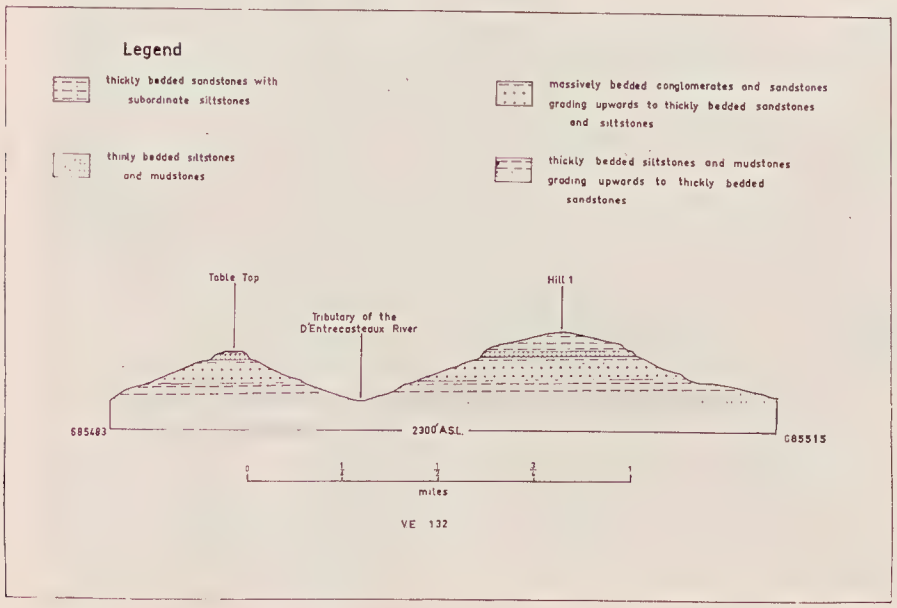
Legend
thickly bedded sandstones with subordinate siltstones
massively bedded conglomerates and sandstones grading upwards to thickly bedded sandstones and siltstones
thinly bedded siltstones and mudstones
thickly bedded siltstones and mudstones grading upwards to thickly bedded sandstones
Table Top
Tributary of the D'Entrecasteaux River
Hill 1
685483
2300' A.S.L.
685515
miles
VE 132

Fig. 2.—Section showing slopes developed on various rock types due to periglaciation.

CONCLUSIONS

Considering the mapped areas of glacial ice action in Fig. 1 together with periglacial and nivational effects briefly discussed above, it becomes apparent that it is possible to account for all features in the landscape of the Mt La Perouse area with one period of glaciation and associated periods of periglacation and nivation. It is recognised that evidence of two periods of glaciation exists in northern Tasmania and of four or more periods of glaciation in other parts of the world and this suggests it is highly probable that more than one period of glaciation occurred in the La Perouse area. It is considered that multiple glaciation is not required by the evidence of the erosional forms, although detailed work on the stratified deposits could demonstrate more than one period of glaciation.

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REFERENCES

DAVIDSON, J. K., 1969: Upper Permian and Lower Triassic Sedimentation and Palynology of the La Perouse Area. *Unpubl. Hons Thesis,* Geology Department, University of Tasmania.

DERBYSHIRE, E., BANKS, M. R., DAVIES, J. L., and JENNINGS, J. N., 1965: Glacial Map of Tasmania. *Roy. Soc. Tasm. Special Publication* No. 2.

JENNINGS, J. N., and BANKS, M. R., 1958: The Pleistocene Glacial History of Tasmania. *Jour. Glaciology,* Vol. 3, No. 24, pp. 298-303.

JENNINGS, J. N., and MABBUTT, J. A. (Editors), 1967: *Landform Studies from Australia and New Guinea.* Cambridge at the University Press, pp. 9-10.

LEWIS, A. N., 1925: Notes on a Geological Reconnaissance of the Mt La Perouse Range. *Pap. Proc. Roy. Soc. Tasm.* Vol. 59, pp. 9-44.

————, 1944: Pleistocene Glaciation in Tasmania. *Pap. Proc. Roy. Soc. Tasm.* Vol. 78, pp. 41-56.

————, and MURRAY, F. N., 1934: Glacial Features in the D'Entrecasteaux Valley. *Pap. Proc. Roy. Soc. Tasm.* (pub. 1935), Vol. 69, pp. 87-90.

MONTGOMERY, A., 1894: Glacial Action in Tasmania. *Pap. Proc. Roy. Soc. Tasm.* Vol. 28, pp. 159-69.

NICHOLLS, H. W., 1898: Notes on the Geology of Mt La Perouse. *Pap. Proc. Roy. Soc. Tasm.,* Vol. 32, Abstract of Proceedings, p. xlvi.

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PLATE 1.
Fig. 1—Aerial photograph of the Lune Cirque. Scale 1" = ¼ mile.
Fig. 2.—Oriented siltstone fragments formed by present periglacial activity.

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